

GEOM 3002: Lab 3
INTERPRETATION OF LANDFORMS AND SURFACE MATERIALS
IN AERIAL PHOTOS

NAME: _____ Student #: _____

Due: October 3, 4 at the beginning of your lab period.

Total marks: 54 ÷ 10.8 = 5% of final course grade

Circle the correct answer for each set of choices or complete the answer as appropriate.

Make sure you also study the example photos as they have interesting variants of the features or landforms that may be similar to questions given on the test.

Folder 1: Till Landforms - Glacial Moraines and Drumlins

Glacial moraines can be quite varied in appearance. They all consist of glacial till that has grain sizes from clay through silt, sand and gravel, and they may include cobbles or boulders. The proportions of each grain size can vary significantly between moraines. We will consider two categories: 1. ground moraine and 2. ablation/ridge moraine. A brief summary of their differences follows.

Ground moraine is deposited directly beneath the ice by pressure as the ice advances. The till in ground moraine is often called 'basal till'. It has more fine grained particles than other moraines because water was not actively washing the fine grains away.

Ablation moraine is composed of till within the general ice body that settles out when the ice melts. Since there is water present in melting, some of the fine grained particles (clays and silts) are removed leaving the remaining till coarser (more sandy) than ground moraine.

Note: There are also several moraine types known generally as 'Ridge moraines' that include deposits at the ends of glaciers ('end moraine' - sometimes in a series called 'recessional moraines'), the sides of valley glaciers (lateral moraines) and between ice lobes (medial moraines). When the ice melts they settle out forming ridges. They have coarser grains than ground moraine as some of the fines are carried away by water. Ridge moraines and ablation moraines often grade into each other and are hard to tell apart unless the photo scale is small enough that the ridge can be seen as distinct with two sides. We will therefore consider ablation and ridge moraines together; i.e., just call all examples 'ablation moraine'. You don't need to identify ridge moraines unless the ridge is plainly visible.

Ground moraine and ablation/ridge moraine are similar in many ways in remotely sensed images.

Deranged drainage and mottled texture can be found in all, but they are coarser and less evident in ridge and ablation moraines unless the photo scale is small.

Ablation moraines, being coarse grained, often do not have a distinct drainage pattern, but if they do it is mottled with larger/coarser mottling than ground moraines and sometimes they have a brainy texture (see example photos). Both ablation and ridge moraines may have kettle holes (hence the Bird and Hale term Kame-Kettle moraine) that are filled or not filled with water (depends on permeability of underlying material).

Topography is more pronounced in ablation and ridge moraines (rolling) than ground moraine (undulating).

Land use is low intensity agriculture and forest in all moraines, but there is even less agriculture in most ablation and ridge moraines.

1. The type of moraine at around A is **Ground Moraine** while around B it is: **Ablation moraine** . Clues that distinguish these two types of moraine include:

The topography around A is undulating _____, whereas around B it is rolling _____.

The gully shape (at C) is V / U / C, indicating coarser till than around A where the gully shape is V / U / C

The land use is **more intense / less intense** around A than around B.

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2. Study the bright field in the upper right. What type of moraine is this? **ground moraine.**

The image texture indicative of this moraine landform is: Botryoidal / Flecked / Mottled / Brainy.

The drainage pattern is: Rectangular / Pinnate / Centripetal / Deranged.

Example photos: Make sure you turn the photo over to see an example of ground moraine in northern Ontario. Here the distinguishing criteria are less evident but there is definitely less farming due to climate and poor soils.

Check the other example photos as well. There are two showing Ablation moraine with a type of brainy texture and one showing end moraines in alpine glaciers. Try to imagine such features at the edge of huge ice sheets extending over the content.

Drumlins are oval hills formed beneath the ice from basal till similar to that in ground moraine. They are distinguished by their topographic shape with a steep side pointing against the direction of ice advance and a shallow side pointing in the same direction as ice advance. They can range from short and tear drop shaped to long cigar shaped ridges. You have to see well in stereo to distinguish the topographic relief of small or low drumlins. Sometimes the steep side is forested and the shallow side is farmed. Sometimes they occur in groups, called drumlin fields, as near Peterborough. If so, areas between drumlins can be quite wet and poor for farming.

3. What are the lines visible at A? Gullies / stream erosion

The direction of ice advance was from the: N / NE / E / SE / S / SW / W / NW.

Note the esker at B.

Check the drumlin example photos 5.2 and 6.6 from Bird and Hale. Photo 5.2 also has a long esker running from the bottom left (A, 1) to at least (J,25) with many sand and gravel quarries in the mid to upper portion.

Folder 2: Ice Contact Stratified Drift Landforms - Eskers and Kames

Ice contact stratified drift is material that settled out in melt water while in contact with the ice. It is stratified because it is deposited in layers and sandy because fine grains (silt and clay) were carried away by the water. Eskers are long sinuous ridges of sand and gravel deposited in a running water environment (high energy) on streambeds that were within or beneath the ice.

Kames are mounds or hills of sand (and some gravel) deposited in depressions in the ice by running water. When the ice melted, these layers of sand settled down to ground level.

Both are distinguished by their shape, uniform or smooth texture, little farming, possible quarrying, and lack of drainage pattern (meaning they are permeable coarse-grained soils). They often occur together in esker-kame complexes. Kames can be much more difficult to ID as they often are simply a hill(s) surrounded by other landscape cover types and/or sitting on ground or ablation moraine, or outwash.

1. For the kames visible at A, True or False:

A distinct drainage pattern is visible. T / F.

The soils of these kames are impermeable. T / F.

The internal drainage of these kames is good. T / F.

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Note the esker running down the centre of these photos (part of it is indicated at B).

2. Many kames in these photos have gullies descending their steep slopes. The V - shaped gullies indicate that the kames are composed mostly of till / clay / silt / sand.

Why are the eskers frayed or braided at the end? Due to multiple streams and deposits.

Check out the road at A: Curves were put in to go around the kames. If the scale is about 1:100,000, a change in alignment of 2mm or so on the photo is about 200m on the ground, representing a significant cost.

Note the example photos. One is from northern Ontario where land use is not present unless it is forest harvesting or mining. However, linear eskers are still often visible. Individual or groups of Kames are harder to distinguish.

Folder 3: Outwash Landforms – Outwash Plains

Outwash plains form when a ridge moraine that serves as a dam for melt waters ruptures. Water flows quickly out over the terrain beyond the ridge moraine carrying large amounts of sediment. The coarse grains settle out in this high-energy environment close to former lake while the fine grains are carried further away into rivers, lakes and oceans. Thus, the outwash plain is sandy, with:

- flat topography (except when depressions, also called 'kettle holes', are present from melting blocks of ice – sometimes we call this 'Pitted Outwash'),
- smooth texture due to uniform sandy soil composition,
- no visible drainage patterns due to good internal drainage (except for possible remnant streaks from the river channels that brought the deposit, called channel scars),
- low intensity agriculture (except for some crops in the south such as tobacco or orchards that like sandy soils) or in the north, forest (species such as pines that like sandy soils).

1. Landform at A. **Outwash plain**

The lines around the upper left A are called: **channel scars**

The landform type at B and C: **ground moraine**

Straight line at D indicates what feature: **dam**

2. The outwash soils are (circle two): **permeable / impermeable / poorly drained / well drained**.

What features are present around A that indicate this outwash initially had melting ice blocks? **Depressions or Pits**.

Folder 4: Glacio-lacustrine landforms - Lacustrine plains, Beach Ridges

Glacio-lacustrine plains are flat deposits of fine-grained soils (silts and clays) that settled out of a lake (or in a sea they are glacio-marine sediments). If the climate is good, agriculture is intense (many fields of varying tone, especially in early summer). Drainage is relatively poor so ponding, drainage ditches or tiles may be evident.

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Beach ridges are arc-shaped ridges of former glacial lake shorelines. They are sandy as the environment was high energy (waves). Where a lake has receded or dried up, they may be difficult to ID as the lake may not be present in the image.

1. Around A, in addition to the obvious pattern of contrasting field cover types, a photo texture is faintly visible that is the same as the texture around B. That photo texture is: **Mottled**

Two glacial landforms are present around A; one was deposited on top of the other. Name the landforms:

1. **Glacio-lacustrine**; 2. **Ground Moraine**.

Which was deposited first? **Ground Moraine**.

Note the pinnate drainage patterns at C, indicating high silt content. These gullies are relatively stable as evidenced by the presence of vegetation.

Folder 5: FLUVIAL LANDFORMS - Point bars, Oxbow lakes and deposits, natural levees, backswamps

Point bars, oxbow lakes and oxbow deposits, and natural levees are typically distinguished by their shapes, which are easily seen due to the contrast in tone with their surroundings, or their topography (specifically for levees).

- Given a river is present in the photos, point bars are arc shaped ridges on the insides of river bends. They are sandy (high energy deposits) and bright if unvegetated. They are like beach ridges only smaller. They are typically bare or sparsely forested, and sometimes have homes on them.
- Oxbow lakes form when erosion on the outside of river bends cuts into a meander downstream, causing the river to cut-off a section and flow straighter. The cut-off section is the shape of the former meander. It often remains filled with water (oxbow lake), but may dry up leaving an oxbow deposit of fine-grained soils (low energy as no moving water in the oxbow), which may support later vegetation growth.
- Natural levees are deposits along the river's edges that form when the river floods. The velocity drops as the water overtops the banks. Sand and silt drop out to form these long ridges. They may have houses on them but they are high-risk flood zones.
- Backswamps may form in the area behind the levees when the water in the river rises high enough to flood the area but not overtop the levees. As the energy level is low, these are areas of heavy fine-grained soils with poor drainage. They may be farmed (e.g. Red River) and sometimes artificial drainage may be used, but they may be too wet to farm (e.g., Mississippi bayous). Backswamps could be included under 'Wetlands' but are presented here since they are formed by fluvial (river) processes.

1. Landform at A: **point bars or meander scrolls**

Landform at B: **Oxbow deposit (1/2 for oxbow lake, or oxbow)**

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Also note the outwash plain to the right of B and above B, with its overall smooth texture, flat topography, lack of drainage pattern, lack of intensive land use and gullies around its edge whose V-shape indicate sandy soils.

2. In the photos marked 'T1', 'T2', 'T3':

The scale of the T1 photos is larger than / the same as / smaller than the scale of the T2 and T3 photos.

Oxbows that are dark are filled with short vegetation / peat / sand / water and are typically older / younger than oxbows that are lighter grey, which are filled with short vegetation / peat / sand / water

At A, what needed to be done between T2 and T3 as a result of the oxbow lake forming between T1 and T2?

Road had to be re-aligned

In Example photo 1, besides the labelled landforms, notice the natural levee at A, and the steep slope to the left of the river, which confines it from meandering more in that direction.

In Example photo 2, natural levees are on both sides of the river and covered by trees. This landscape is mostly old beach ridges with wet areas in between that are swampy.

Folder 6: EOLIAN LANDFORMS - Sand Dunes and Loess

Various types of sand dunes can form depending on the amount of sand available, the amount of wind, the consistency of wind direction, and terrain factors. In cross section, dunes typically have steeper slopes on the side that is downwind (the lee side). Note: this is opposite to drumlin cross sectional shape.

- Parabolic and barchan dunes are distinguished by their arc shape. Parabolic dunes have the horns pointing into the wind; barchan horns point downwind. Parabolic dunes generally form when subsurface sands are moist and they often have vegetation anchoring the horns, or are completely vegetated (shoreline dunes often have shrub vegetation; forest may occur in formerly active dune areas). Vegetation implies the dunes are more stable and not as fragile. Barchan dunes form in dry environments.
- Transverse dunes are long ridges perpendicular to the wind. They can develop from barchan dunes if sand supply is high enough to allow the barchan dunes to coalesce.
- Longitudinal dunes are long ridges parallel to the wind with symmetric cross sections.
- Star dunes result from many wind directions. We do not have examples of these.

1. Erosional feature evident around A that is associated with dune development: **Blowouts (bare soil)**

Landform at B: **parabolic dunes (0.5 for barchan dunes)**

The dominant wind direction is towards the N / S / E / W / NE / NW / SE / SW.

At C, why was the road direction changed? **flooded area**

2. The dunes in these photos often appear to have both sides equally steep. However, the two dunes at A have a distinct shallow side and a distinct step side. Their type is: Transverse / Longitudinal / Parabolic / Barchan.

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Make sure you check Example 1, parabolic dunes (a good example at A) in a forested area that is undergoing harvesting.

Example 2 shows longitudinal (sometimes called 'seif') dunes and read the back of the photos. You'll be surprised sand dunes form(ed) in this location.

Loess is a windblown deposit comprised mostly of silt that is deposited over a broad area at various thicknesses. It is distinguished in airborne imagery primarily by pinnate drainage, heavy erosion (many gullies, which may be U-shaped), a slightly fuzzy or out of focus appearance, and intense agricultural land use where the climate allows it) leading to varying tones between fields. If loess is thin and overlies till, the mottled texture of the till underneath may also be apparent. It is not a common landform in Canada so we do not have many photos; take care of the ones we do have.

3. In the right photo, pinnate drainage is most evident in the top / bottom / centre of the photo. In the upper part of the photos, the undulating terrain, faintly mottled texture, and deranged drainage indicating the landform deposited underneath (i.e. before) the surface loess is ground moraine.

In Example 3, note that pinnate drainage is evident but the gullies are generally vegetated, indicating the slopes are stable.

Folder 7: WETLANDS

Wetlands consist of partially decomposed vegetation and soil mixed together. The tone of bare organic matter and wetland soils is generally very dark. If covered in vegetation, the vegetation is often short (shrubs, grasses etc.) where the water table is near the surface and in patches resulting in mixtures of tones and blotchy texture (see Q1, Q2 photos). If covered by short vegetation, the tone is medium grey and can sometimes be quite high in reflectance. If water is not always very close to the surface, a uniform canopy cover of trees (e.g., spruce (darker in tone)) or shrubs may develop, particularly in more northern areas. In this case, tone and texture are more uniform. The topography is flat and the drainage is poor, meaning there may be open water but drainage patterns are not visible. Wetlands can be classified in many ways. The Canadian system (used in most countries) includes 5 broad classes, marshes, bogs, swamps, fens, and shallow water as well as sub classes of these. In good climates, intense farming (e.g. vegetables) may be present but drainage using tiles or ditches is generally required. Peat extraction (e.g., the Alfred Bog east of Ottawa) and draining of wetlands for farming has been very common, resulting in losses of most of the wetlands of southern Ontario and elsewhere in the U.S. We will not distinguish between types of wetlands but will call all of the above 'Wetlands'.

1. a. What type of activity is that causes the dark stripes in this photo? (Hint: think about horticulture) Peat farming
 b. (turn photo over) In the swamp area what human made feature indicates that the water level is consistently high? Drainage ditch.
2. Around A is a fen. The grey lines are short vegetation / black spruce trees / water / peat, while the dark areas between the greyish lines are short vegetation / black spruce trees / water / peat.

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Note also the raised bogs at B.

Folder 8: Permafrost Landforms

Permafrost landforms result mostly from freeze-thaw processes at the surface. The most common are ice wedge polygons (multiple polygonal cracks in surface material), thaw lakes (shape is nearly rectangular due to two dominant wind directions, or circular when many wind directions), and beaded streams (ponds form along a stream course at locations of permafrost melting). Pingos (mounds thrust upwards by freezing) are rarer but very striking on the ground and in air photos. Solifluction lobes or stripes (marks of unfrozen surface soil slipping over a frozen layer below) are common but difficult to identify.

1. Landform at A: **Pingos**.

The landform at A in the centre of the right photo looks like a ring. Why? **collapsed and filled with water.**

Landform at B: **Beaded Stream**

Landform at C: **Ice Wedge Polygons**

2. The prevailing winds are oriented along the axes (select two): **N-S / NE-SW / E-W / SE-NW.**

Besides the thaw lakes, the most evident permafrost landform is (look closely):

_____ **ice-wedge polygons** _____.

Why does the tone vary within many of the lakes? **Accept logical answers such as**
sediment in lakes; shallow – can see bottom **Don't accept sun angle-view angle variations as**
that would cause tonal differences between photos for a given lake and that does not appear to occur.

3.