

Laboratory Exercise #4 – Geologic Surface Processes in Dry Lands

Section A – Overview of Lands with Dry Climates

The definition of a dry climate is tied to an understanding of the hydrologic cycle in a region. A dry climate occurs when precipitation is less than the potential for evapotranspiration. For example, in Laredo, TX the average precipitation is 18 inches per year whereas the potential for evapotranspiration is over 60 inches per year. So Laredo, like most of South Texas, obviously has a dry climate.

There are two types of dry climates: steppe (semi-arid) and true deserts (arid). A true desert has less than 10 inches of precipitation on average in a year; whereas a steppe has greater than 10 inches of precipitation. Generally, steppes are present on the periphery of true deserts (Figure 1).

Additionally, there are three types of deserts:

Subtropical deserts – located between 20 to 30° away from the equator.

Mid-latitude deserts - located between 30 to 60° away from the equator in the rainshadow of large mountain ranges.

Polar deserts – located between 60 to 90° away from the equator in extremely cold regions that have minimal precipitation.

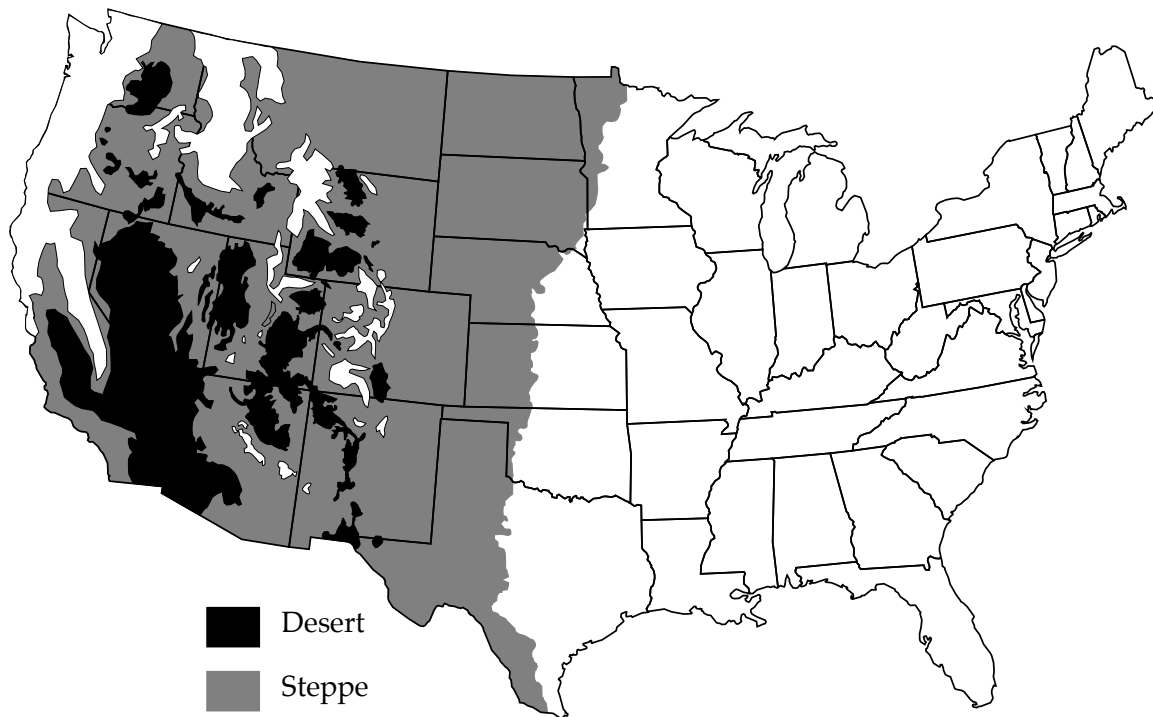


Figure 1. Map of the continental United States showing the distribution of steppes and deserts.



Figure 2. Picture of sand dunes and other desert features

The two major processes that result in erosion and deposition of loose unconsolidated material on the earth's surface is running water (fluvial processes) and wind (eolian processes). In regions with dry climates it would be natural to assume that eolian processes would dominate over fluvial processes. However, precipitation events in dry climates, while sporadic, are commonly intense. Downpours associated with isolated thunderstorms can dump inches of precipitation over a small area in the course of an hour or two. These downpours result in a rapid accumulation of runoff in intermittent streams that can cause flash floods. During these flash floods, significant erosion can form deep stream valleys and transport large quantities of sediment.

An additional consideration is that water has a density that is approximately 700 times greater than air. Therefore, water has a greater capacity for moving sediment and altering the landscape than wind. Consequently, wind can only move sediment as large as sand whereas water can move gravel, or even boulders during extreme flood conditions.

However, eolian processes do play a significant role in dry lands. In some places, the desert landscape can be shaped by moving sand in the form of sand dunes (Figure 2a). However, in most of the world's deserts, barren rocky landscapes largely devoid of sand are more the norm. This is especially the case for the western deserts in the United States. Even in rocky landscapes

eolian processes generate features which are not readily observable at the map scale but can be seen with the eye on the ground. **Pedestals** are sand blasted boulders that result from the fact that wind can only lift sand grains to a height of a few feet above the surface (Figure 2b). **Desert pavement** is a pavement of gravel formed when wind blows all the clay, silt, and sand away from a soil (Figure 2c). A **ventifact** is a rock that has one or more of its sides polished by natural sandblasting (Figure 2d).

Questions:

1. Name three states in which steppe exist in the continental United States.
2. Name three states in which true deserts exists in the continental United States.
3. What type of desert dominates most of the western continental United States?
4. Name two landscape features in which water occasionally flows that is formed by fluvial processes (water-driven).
5. Name three features that are formed by eolian (wind-driven) processes.

Section B – Basin & Range Landscapes: An Example of a True Desert

Much of the western continental United States is dominated by a Basin and Range topography. Tectonic activity has generated fault-bounded valleys that are surrounded by long linear, fault-block mountain ranges (Figure 3). Much of the Basin and Range has a true desert climate with less than 10 inches of rain per year on average. However, even in this desert environment fluvial processes dominate over eolian processes.

A number of features develop as a result of episodic fluvial erosion associated with intense isolated thunderstorms, which are the dominant type of precipitation in this region. Steep mountain valleys form intermittent, upland streams that downcut into **fault-block mountain**

ranges. Sediment generated by erosion of upland streams is deposited in a cone-shaped pile of debris, referred to as an **alluvial fan** (Figure 3a), where the mountain stream enters an adjacent valley. A **bajada** is a series of many alluvial fans that coalesces along the base of a fault-block mountain (Figure 3a). If a stream flows into the middle of the fault-bounded valley water may collect together in a depression forming a **playa lake** (Figure 3a). Because evaporation is intense in the Basin and Range a **playa lake** can rapidly dry up forming a flat, salt-encrusted plain called a **playa**. While tectonic uplift is active, significant relief exists between fault-bounded valleys and mountain ranges. Within much of the Basin and Range Region the drainage is said to be **internal** because rivers and stream do not flow into the ocean.

Cessation of tectonic activity will over time results in erosion of the mountain ranges and filling in the adjacent valleys with deposited sediment thus decreasing overall relief (Figure 3b). An isolated, erosional remnant of a mountain range is called an **inselberg**. The sedimentary material that is deposited in the valley as a gently sloping plain is called a **pediment**.

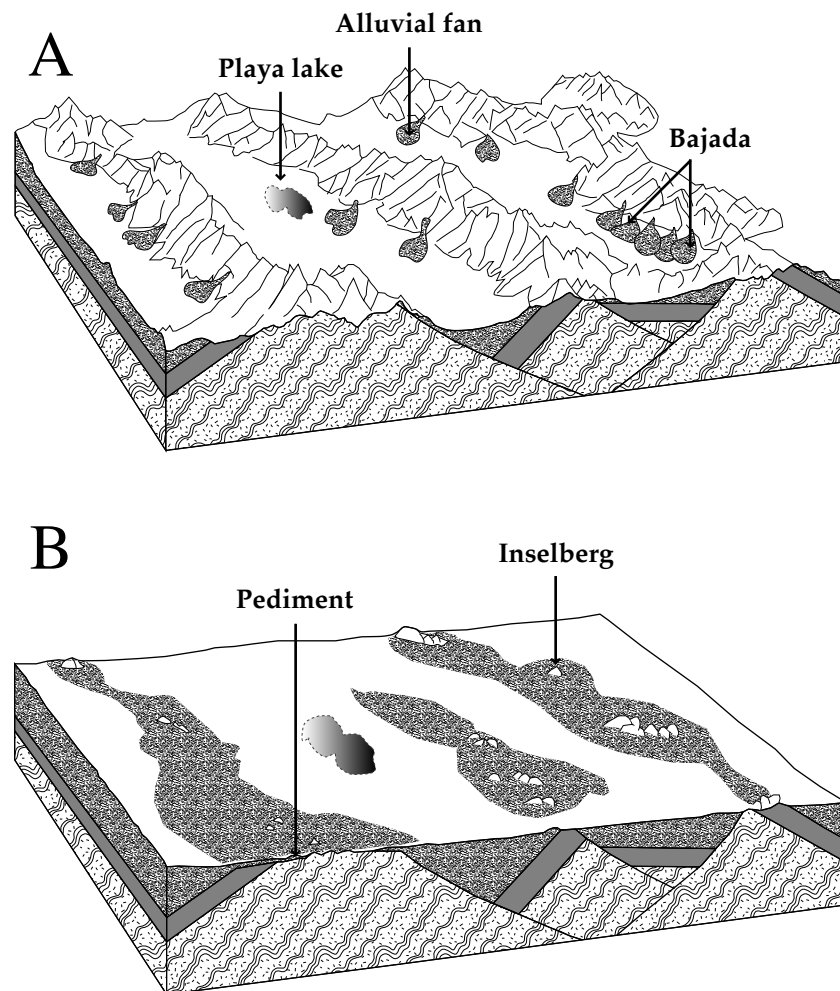


Figure 3. Stages of Basin and Range landscape development. a) Early, tectonically- active stage. b) Late, tectonically-inactive stage.

Questions:

6. What is the latitude and longitude of Wild Rose Peak (in the south-central part of the map)? Also, indicate its elevation which is written next to the peak on the map.

7. What type of desert (of the three types discussed previously) is depicted by this map?

Hint: note the latitude of this map.

8. By examining Figure 3 infer what stage of landscape evolution typifies Death Valley and adjacent areas. Hint: examine one of the raised relief maps.

Early Stage or Late Stage

9. Discuss what stage of landscape evolution will exist in the Death Valley in a few million years with erosion of the adjacent mountains continues and tectonic activity ceases.

Early Stage or Late Stage

10. Where is vegetation most common (note the color for vegetation in the map legend)?

In Valleys or On Mountain Ranges

11. In the valleys around what types of landscape features do you find vegetation?

12. Why is most of the water at the bottom of Death Valley extremely salty? Hint: the heat temperatures at the bottom of the valley increase which flux of the hydrologic cycle. Explain in detail!

13. What type of lake is present at the center of Death Valley ?

14. What type of streams dominate this region? Continuously Flowing or Intermittent

15. Exam the curved contour lines located in Death Valley and centered roughly at $36^{\circ} 40' N$, $117^{\circ} 15' W$. What type of desert feature do these contour lines represent?

16. Which compass direction is Death Valley Wash flowing in? (This stream is located in the north central part of the map.)

17. What is the map symbol for sand dunes ? (Look closely at the area $36^{\circ} 37' N$, $117^{\circ} 10' W$).

18. Roughly what percentage of the Death Valley desert landscape is comprised of sand dunes as labeled on the map? Does this make sense given the definition of a desert?

19. The southwest side of Death Valley (along the entire eastern side of the Panamint Range) is an example of what type of desert feature? Hint: around $36^{\circ} 15' N$, $116^{\circ} 52' W$.

20. Find the lowest elevation in the middle of Death Valley and indicate this elevation.

21. Measure the horizontal distance between Wild Rose Peak and the lowest elevation in the middle of Death Valley.

22. What is the slope between Wild Rose Peak and the lowest elevation in the middle of Death Valley? (Remember slope is rise / run ; The rise is typically in feet and the run is in miles.) Is this a gentle or steep slope; refer to slope guidelines from lab 3.

Examine the area of the map around the town of Lathrop Wells (NE corner of the map). The landscape here looks much different than that present in Death Valley. Answer the following questions.

23. What type of desert feature (from Figure 3) are the Skeleton Hills ?
24. What type of desert feature (from Figure 3) is present in the region between Skeleton Hills and the town of Death Valley Junction ?
25. The land mentioned in question 24 represents: Early Stage or Late Stage ?
26. Calculate the slope between the benchmark at Skeleton Hills to the town of Death Valley Junction. Is this slope gentle or steep when compared to the slope calculated in question 22 ?

Section C – Steppe Landscapes: South Texas Example

Remember a steppe is a semi-arid region with greater than 10 inches of precipitation per year. In tectonically inactive areas such as South Texas the dramatic landscape features observed in the Basin and Range are largely missing. However, smaller (eye ball scale) features (Figure 2) associated with eolian processes are evident. In terms of larger (map scale) features the dominant motif present in semi-arid (and for that matter arid) regions is the presence of large permanent rivers that are sourced from more humid regions with small intermittent tributary streams that only carry runoff after significant precipitation events.

Questions: (Examine Figure 4 on the following page)



Figure 4. A portion of the South Laredo Quadrangle map.

27. What type of river system (upland or lowland) is the permanent river (Rio Grande) in Figure 4. Be sure to give at least three characteristics to support your selection.

28. What type of river system (upland or lowland) are the intermittent streams in Figure 4. Be sure to include at least three characteristics to support your selection.

29. Are there any features on Figure 4 that formed by eolian processes? If so indicate.

30. Based on your answer to question 24, in semi-arid settings, does fluvial or eolian processes dominate in altering the landscape. Back up your answer by examining the features and providing hard evidence from the map (Figure 4).