Structural Geology

Lecture(4)

Folds and Type of Folds

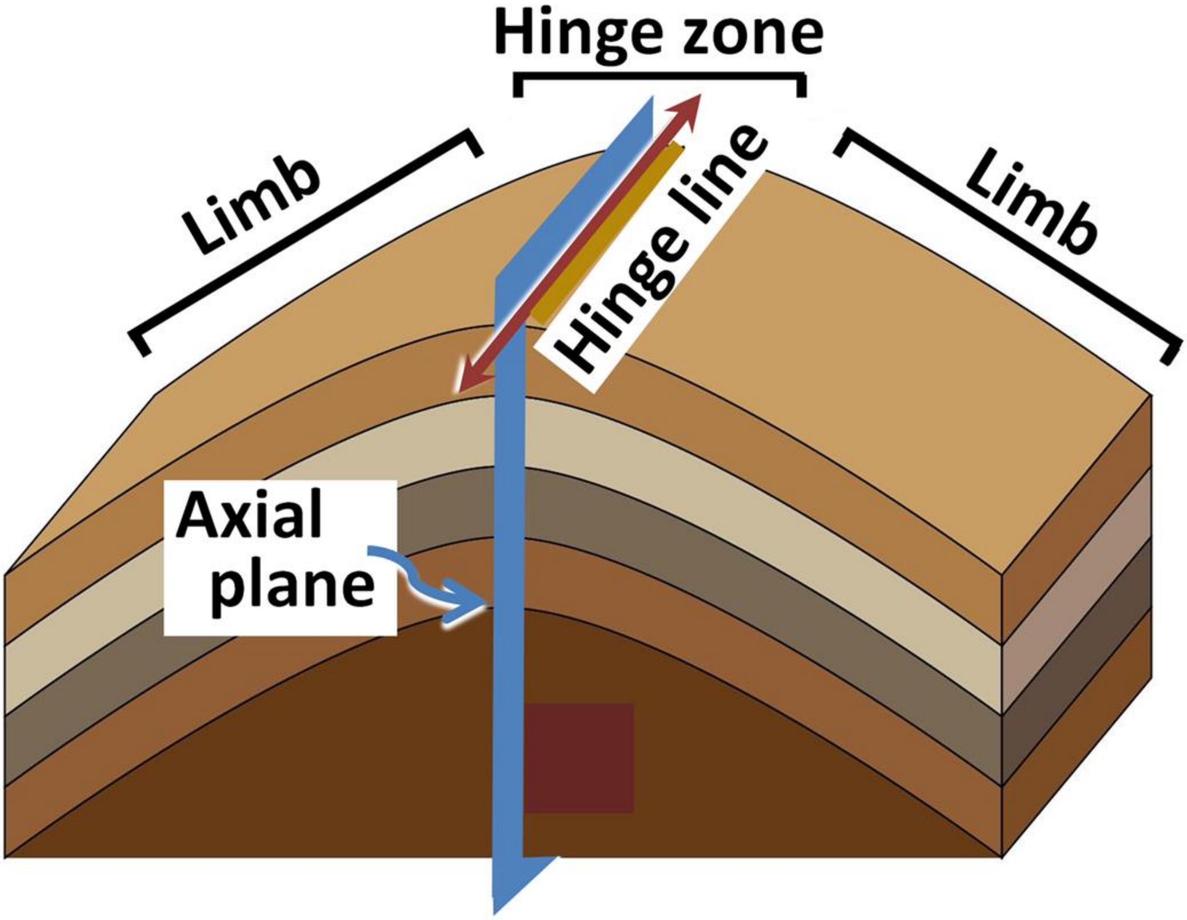
Dr.Abdulhussien N.Alattabi

College of Petroleum Engineering-Alayen university

ANATOMY OF A FOLD

4-1:Folds terminology.

A fold is a geologic structure that is formed by layers or beds of rock being bent or folded. The plane that marks the center of the fold is called the axial plane.The line which marks where the axial plane intersects the surface of Earth is called the hinge line. The areas on either side of the curved hinge zone stick out like arms or legs, and are appropriately called limb.



Fig(4-1) the parts of fold.

4-2:TYPES OF FOLDS

There are three main types of folds: 1-**anticlines**, **2-synclines**, and **3-monoclines**.

1-ANTICLINE

An **anticline** is a fold that is convex: it curves like a rainbow. "A" is for "anticline," and the capital letter "A" represents the shape of the fold.

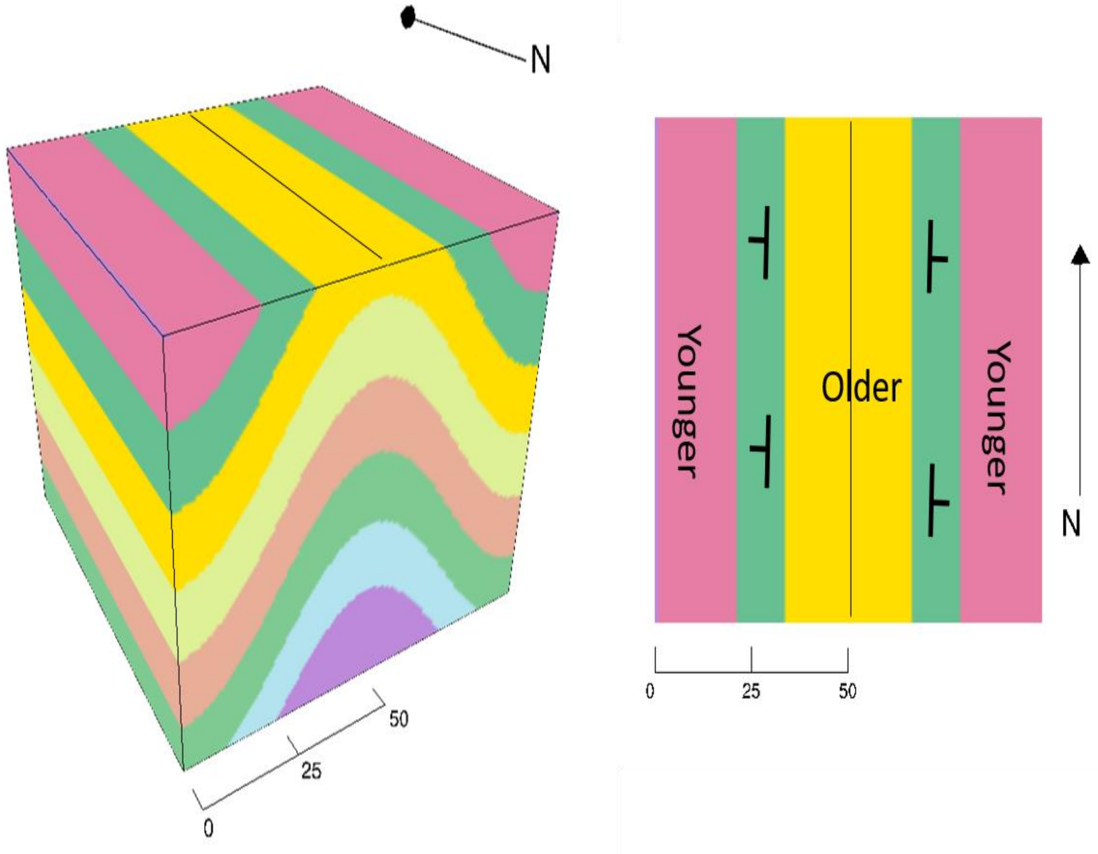


Fig.(4-2): Anticline showing fold hinge line and strike and dip symbols. Older layers appear in the center of anticlines in map view.

Dr.Abdulhussien N.Alattabi- Al-ayen University,E-mail alabdul363@gmail.com

2-A syncline is a fold that is concave: it forms a “U” shape. “S” is the first letter of “syncline,” and a syncline looks like a Smile.

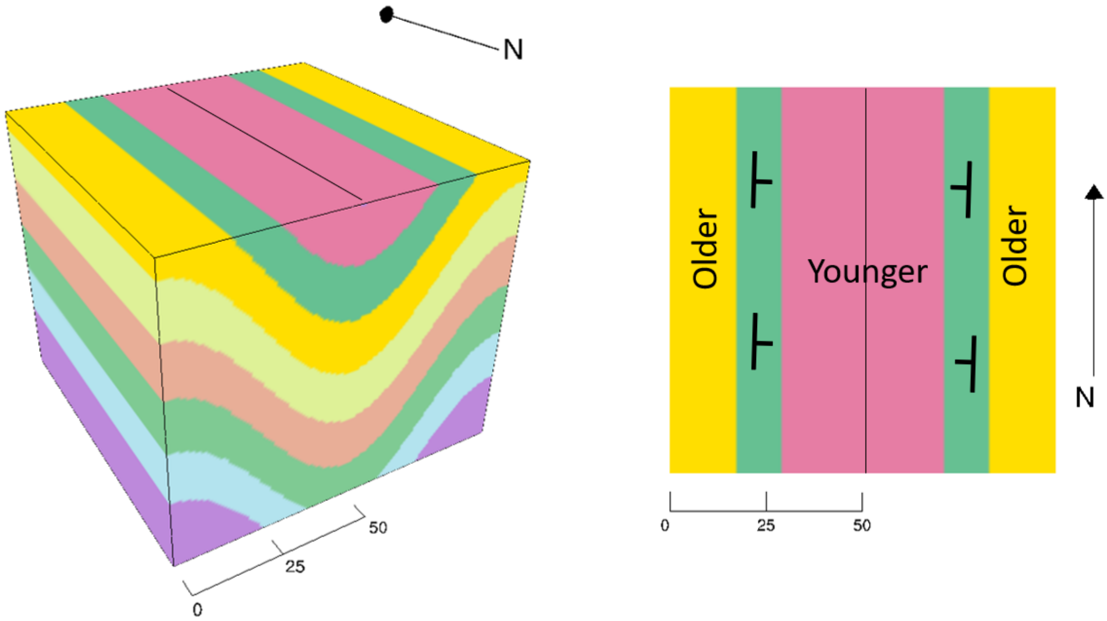
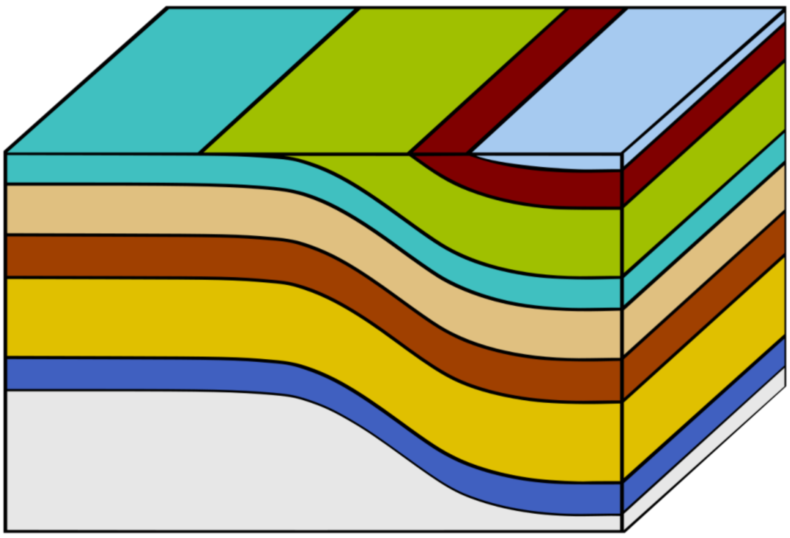


Figure 4-3. Syncline showing fold hinge and strike and dip symbols. Younger layers appear in the center of synclines in map view.

3-MONOCLINE:

A monocline is a special type of fold in which both limbs are parallel but offset to each other. The limbs are horizontal, or nearly so.



Fig(4-4):Monocline fold

 Dr.Abdulhussien N.Alattabi- Al-ayen University,E-mail alabdul363@gmail.com

Once you understand the basic difference between anticlines and synclines, the rest of fold morphology is fairly consistent.

4-3: fold symmetry:

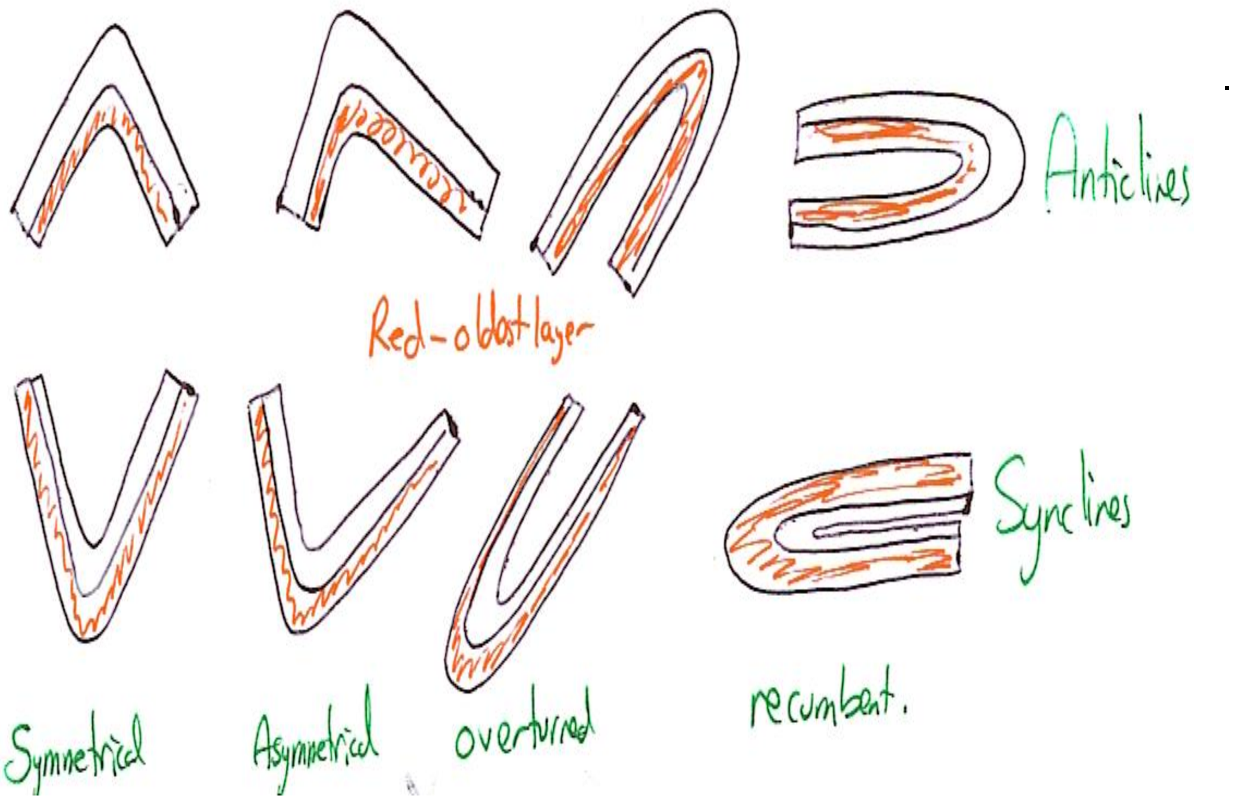
Folds can be symmetrical or asymmetrical

1- Symmetrical folds: the fold limbs have an equal, but opposite angle of dip.

2-Assymetrical folds: are those where one limb dips at a different amount than the other.

3- overturned; both limbs dip in the same direction.

4-Recumbent Fold. e recumbent folds are frequently difficult to recognize in outcrop because the bedding appears horizontal.



Fig(4-5): Types of folds

So far we have restricted ourselves to folds in 2-dimensions, but as I explained in an earlier lecture, to properly understand structural geology, you need to envision these features in 3-dimensions.

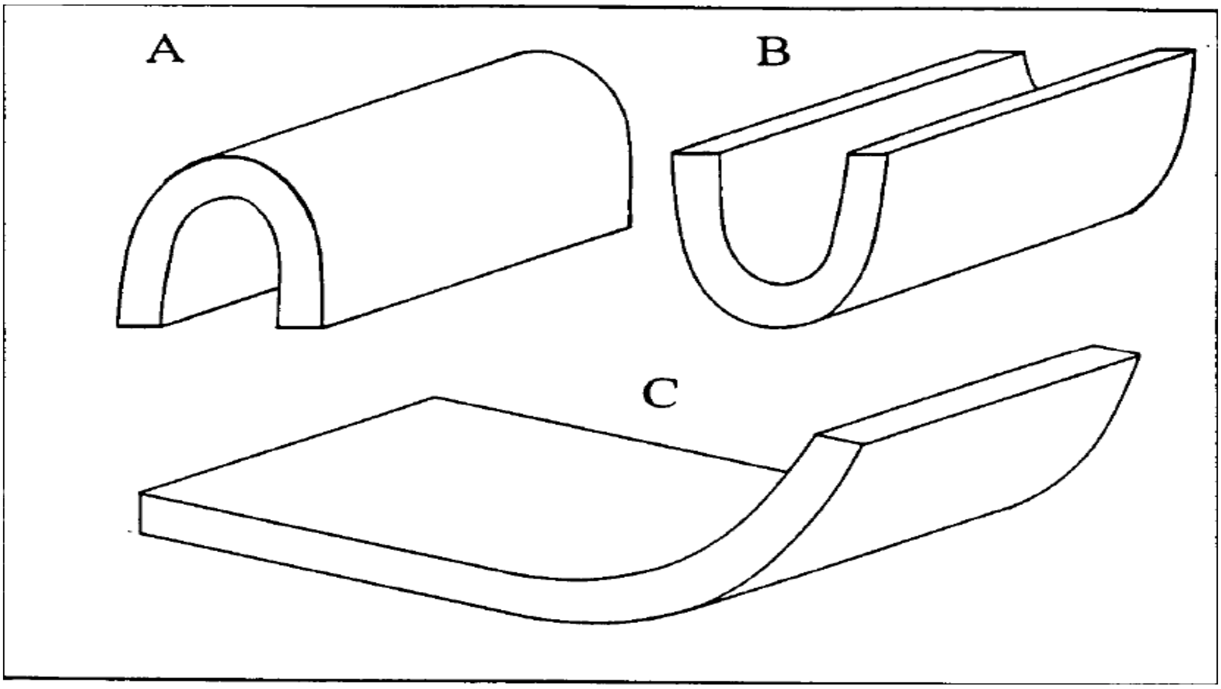


Fig.(4-6):3-d ,A:Anticline,B:synicline,C: Monocline.

All of the previous diagrams were drawn with a horizontal orientation. It is important to note however, that folds need not always be horizontal. The might plunge. Plunging folds are simply folds that have been tilted in one direction.

Dr.Abdulhussien N.Alattabi- Al-ayen University,E-mail alabdul363@gmail.com

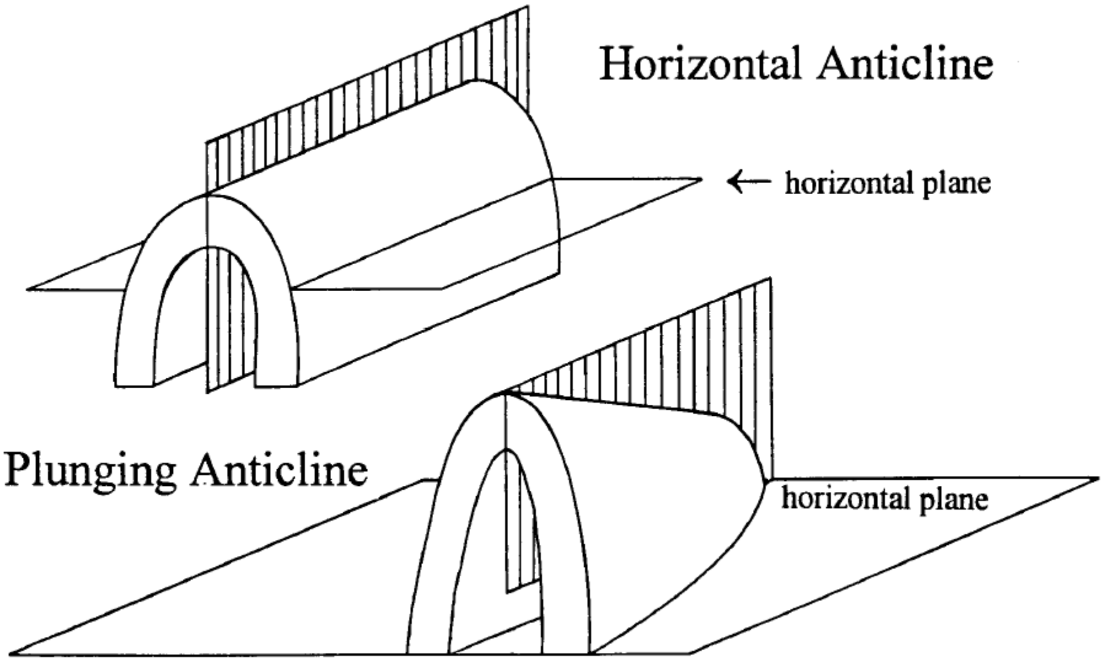


Fig.(4-7): Horizantal and Plunging Anticlines.

Folds are seldom isolated. Rather, they occur in multiples. Limbs are shared between successive folds. In the cartoon below, three anticlines and three synclines are shown. Note that each anticline shares its limbs with adjacent synclines and each synclines shares its limbs with adjacent anticlines. Multiple folds like these are important components of mountain belts throughout the worlds. They are called (big surprise here), fold mountains:

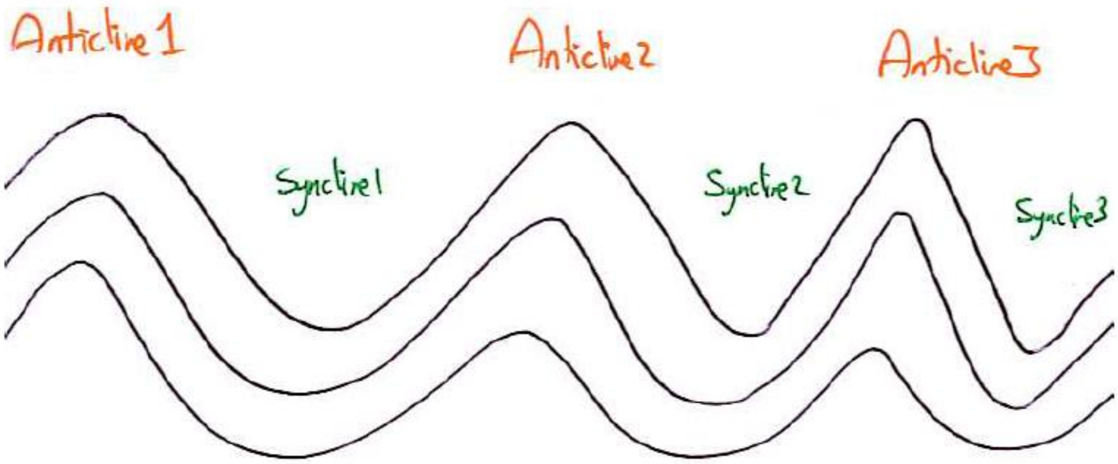


Fig.(4-7):Multiple anticlines and synclines.

Since we are discussing mountains, we should probably reintroduce another important concept at this point; erosion. If you recall our lecture on weathering, I mentioned that mountains or areas of high topography erode more rapidly than valleys (low topography). Following this reasoning, anticlines would be expected to preferentially erode in fold mountains. There is, of course, more to the story than just this. Rocks that are hard and composed of weathering-resistant minerals like quartz (e.g., a well cemented quartz arenite- layer Pg in the adjacent cartoon) will hang around a long time even if they are atop of a mountain. Weaker rocks like shale (Layer Trx) will erode more rapidly even if they crop out in a valley. It is this differing rock competence that leads to the varying topography that typifies most mountain belts, fold mountains included.

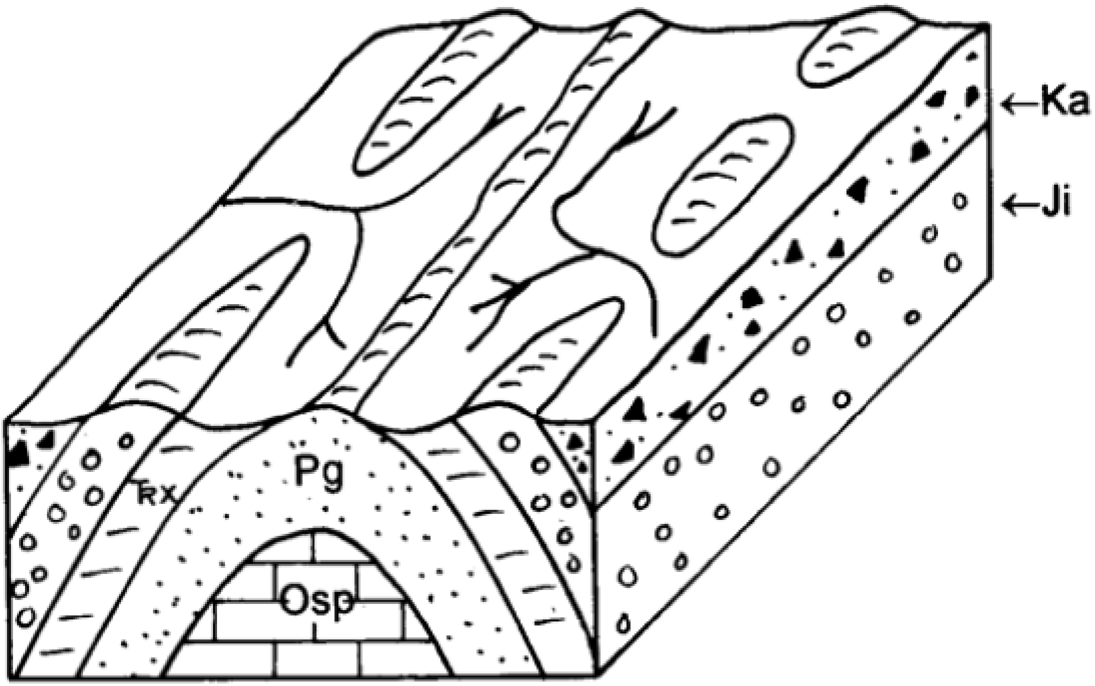


Fig.(4-8):Diffrential erosion in anticline.

 Dr.Abdulhussien N.Alattabi- Al-ayen University,E-mail alabdul363@gmail.com

Fig.(4-9A):Out scale in road cut.

Fig.(4-9)B:Small scale;image is a mere 10 cm across.

4-3:Anatomy of Folds(Terminology):

For a symmetrical fold, this axial plane is perpendicular to the horizontal plane that contains the strike lines of the fold. For asymmetrical and overturned folds, the axial plane is itself inclined. The axial plane is horizontal in recumbent folds. The fold axis is the line that forms where the axial plane intersects the fold. For a horizontal fold, the fold axis is horizontal. As you will soon see, fold axes of plunging folds dip in the direction of plunge. When structural geologists define the fold axis or the axial plane they use different, and some would say, more confusing definitions. The fold axis is defined as the line that connects the points of maximum curvature of a fold at the surface of the Earth. The axial plane is defined as the plane that results when all of the points of maximum

curvature in all of the beds comprising a fold are joined. Maximum curvature is the point on a fold where the dip direction changes. Think of a cross-section of a roof (cartoon below). The crown of the roof represents the point of maximum curvature. The fold axis is simply a series of points located along the crown. For a roof, the fold axis is a straight line, but for a real fold on the surface of the Earth, the fold axis may curve.

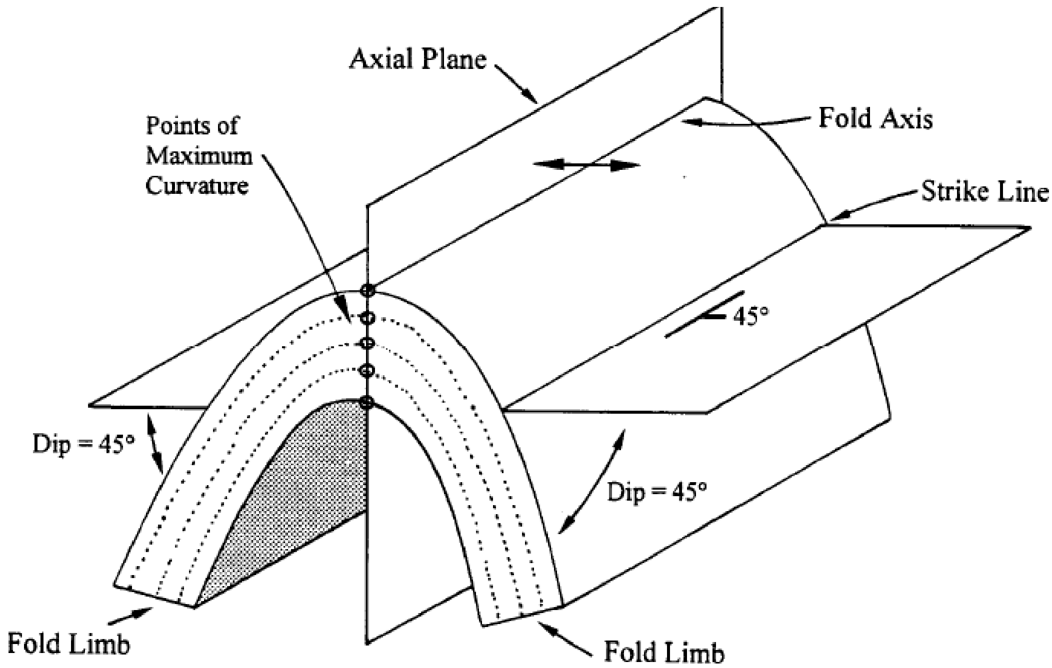


Fig.(4-10): Parts of Fold.

 Dr.Abdulhussien N.Alattabi- Al-ayen University,E-mail alabdul363@gmail.com

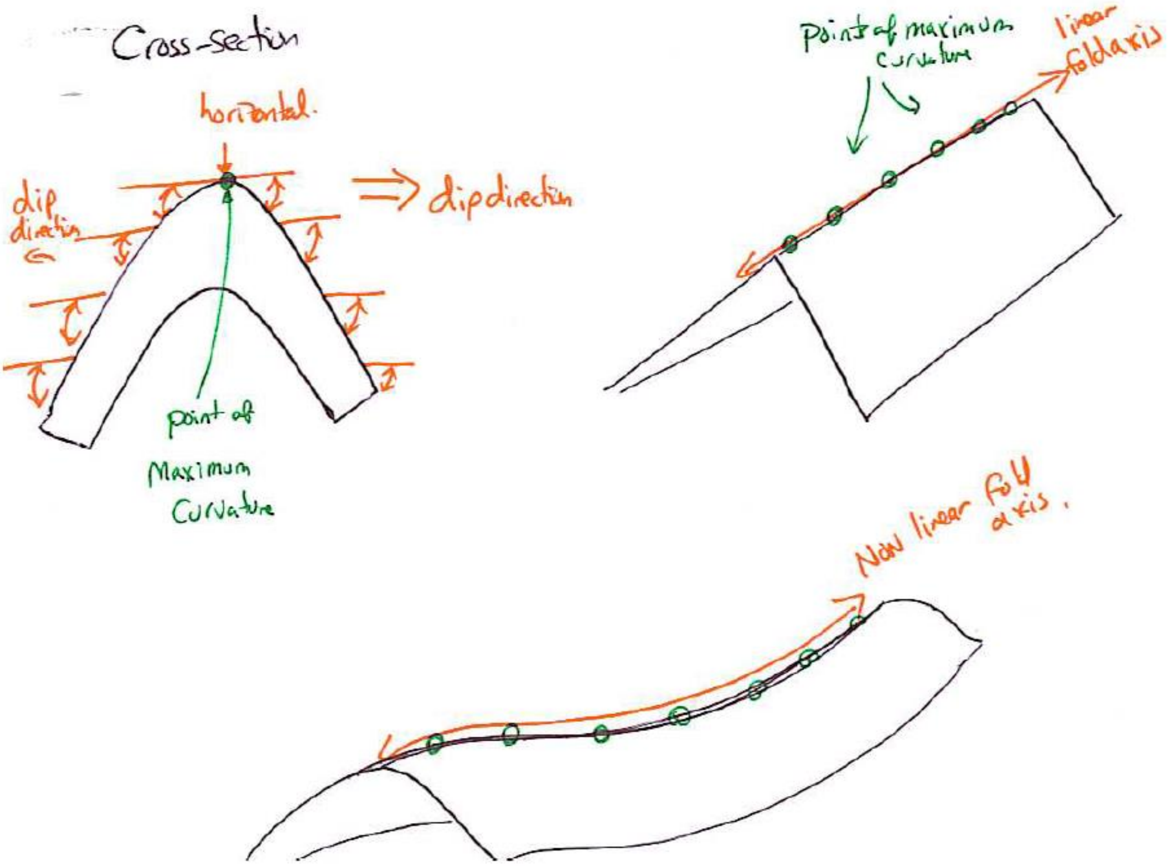
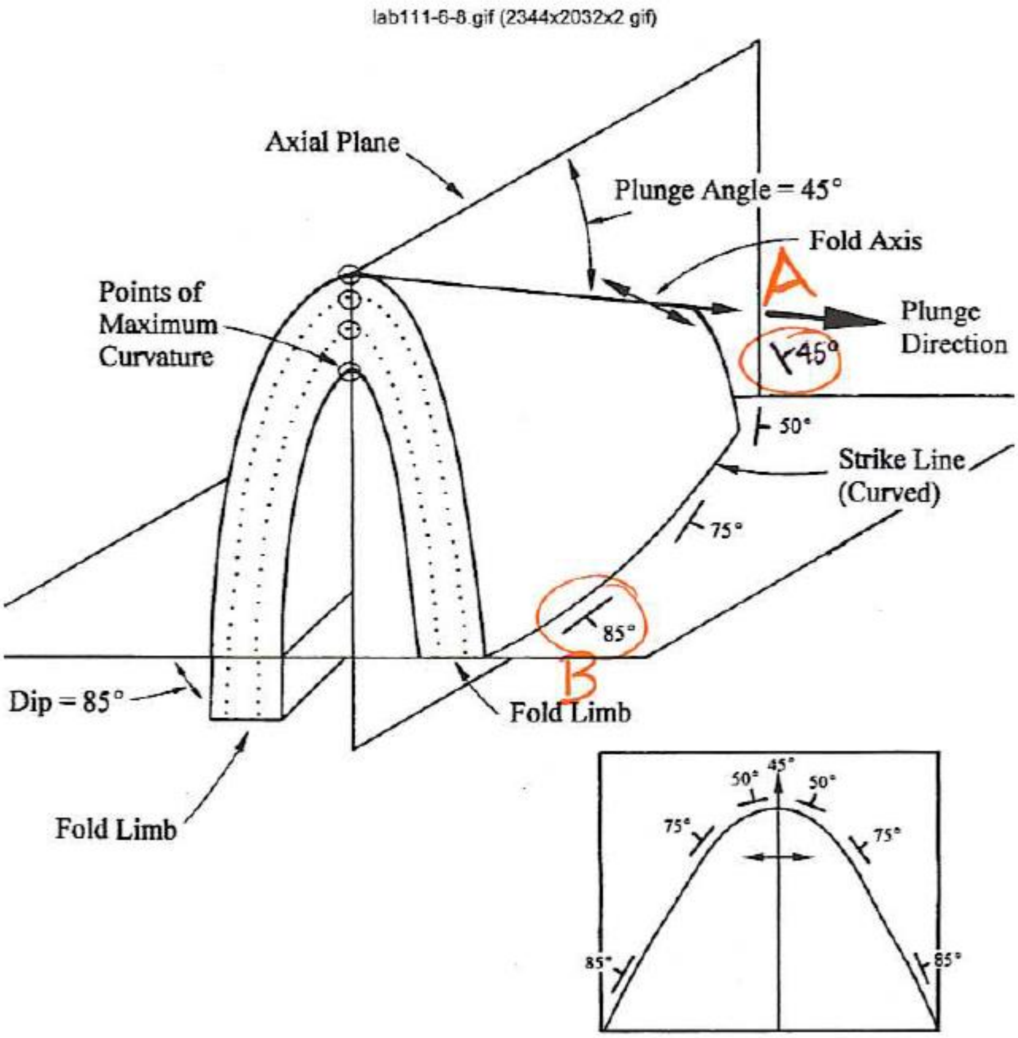


Fig.(4-11): parts of Folds.

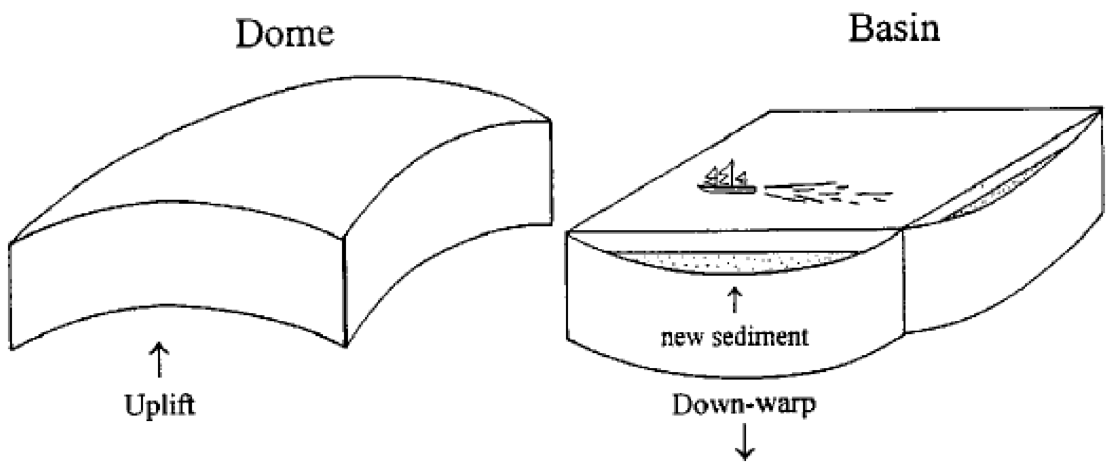
Plunging Folds

4-4: Plunging folds:

Plunging folds add an additional element of complexity that is best just shown in cartoon fashion like the one below. Note that with plunging folds, the strike lines of the fold axes are not consistent but instead, continuously curve from one side to the other. The dips also vary, both in amount and direction. For an anticline, the dip direction radiates away from the center of the fold. Remember this, as we will see another structure with this pattern shortly. The dip at the fold axis (point A in the cartoon) is actually the amount of plunge. The true dip of the limbs only occurs where the limbs trend parallel to the fold axis usually 90˚ from the direction of plunge (point B). Anywhere between point A and point B, the strike and dip of the fold axes varies between the plunge component and the fold limb components. Two more structures must be introduced at this point of the course, and once again, this is best done via graphics (see below). Think of them as fold structures that have two fold axes at 90˚ to one another1 . The first structure is a dome which results when a broad area of uplift occurs. The second structure is a basin. These economically important structures occur when subsidence occurs allowing sediment to be deposited into what more or less amounts to a "hole". The key to understanding these structures (actually the key to understanding all structures) depends on your ability to interpret geological maps. Fortunately, that is the next task in today's agenda.



4-12:Plunging Fold



4-13:Dome and Basin

4-5: Geological maps 2: folds on map We will spend an entire lab session on this topic, so I will not dwell here. I do, however, want to provide you with the most important information about interpreting folds on geological maps. Remember, all of the following diagrams represent the surface of the Earth as a horizontal plane.

1) Horizontal folds result in a series of parallel rock stripes very much like inclined bedding, but... ... with folds, rock layers are symmetrically repeated on either side of the fold axis.

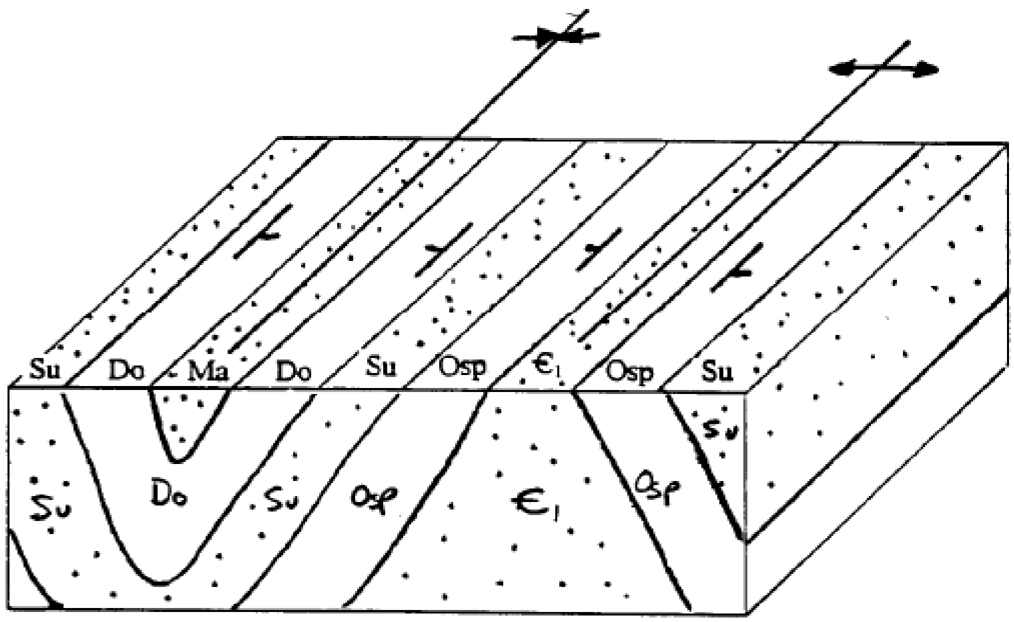
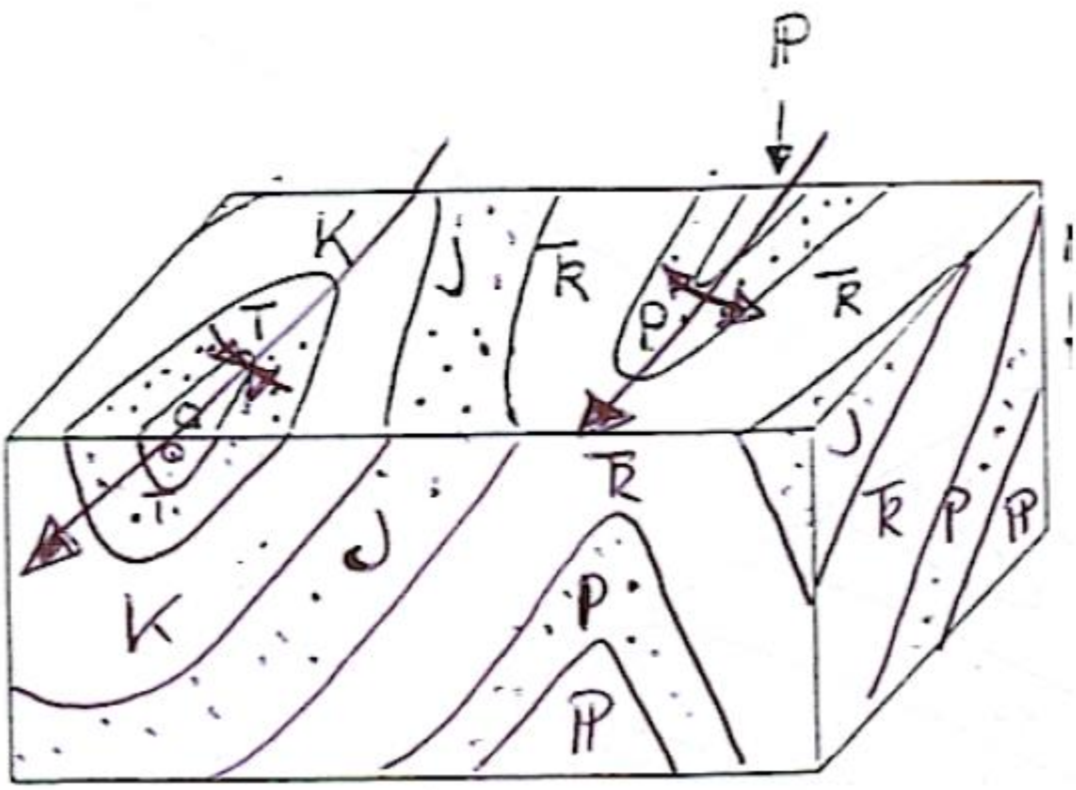


Fig.4-14:Geological map on Synclinal fold.

Dr.Abdulhussien N.Alattabi- Al-ayen University,E-mail alabdul363@gmail.com

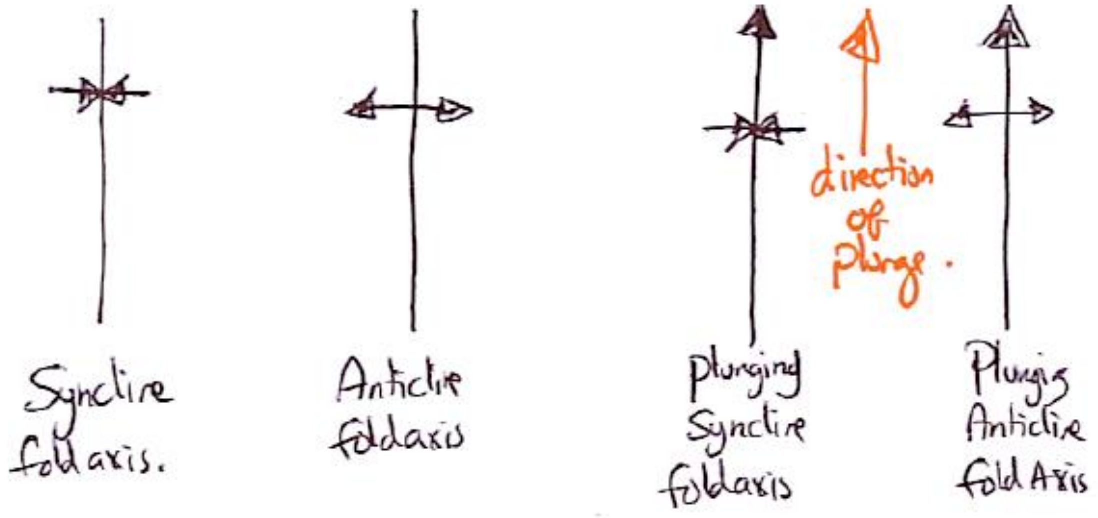
2) For anticlines, the layers get symmetrically younger away from the fold axis, or, if you prefer, in anticlines, the oldest layers are in the middle of the fold. For synclines, the layers get symmetrically older away from the fold axis (the youngest layers are in the middle). Remember this simply rule, and you are half way through mastering folds on maps.



4-15: Geological map for anticline.

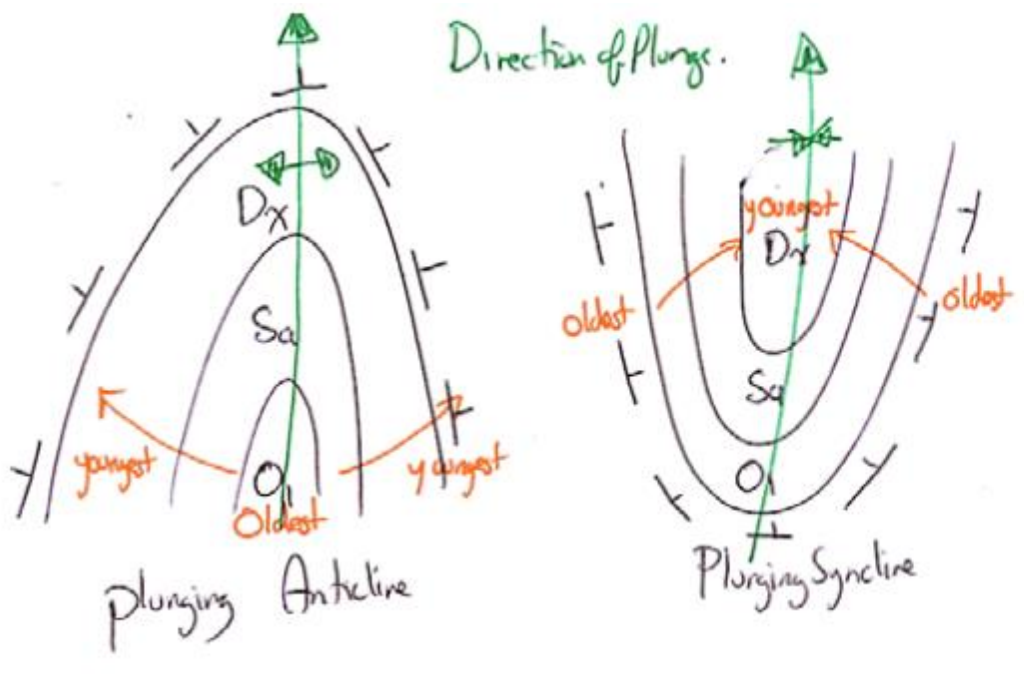
3) Plunging folds result in curved rock strips, but plunging anticlines still have the oldest rocks in the center (perhaps core is a better term here) whereas plunging synclines have the youngest rocks in the center/core. 4) Make sure that you always place appropriate (and correct) strike/dip and fold symbols on your geological maps. Here are 4 more to add to your repertoire.

 Dr.Abdulhussien N.Alattabi- Al-ayen University,E-mail alabdul363@gmail.com



4-16: Fold axis

5) The plunge direction of folds is easily identified if you remember this simple rule; the plunge direction of all plunging folds is always towards the younger rock layers. In my case, I just remember that plunging anticlines always plunge towards the "nose" of the fold. Plunging synclines plunge away from the nose. There will only ever be one plunge direction for plunging folds in GY 111, so once you identify the plunge direction of the anticlines, you just add the same arrow to all fold axes on your map.



4-16: Plunge direction of folds

Dr.Abdulhussien N.Alattabi- Al-ayen University,E-mail alabdul363@gmail.com