

A Stereo Picture Guide to **Folds**

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1998



This view toward the north shows the Madison Limestone, of Mississippian age, folded at the core of Teton Anticline along the leading edge of the thrust belt in west-central Montana. The ridges of the Sawtooth Range are supported by Madison Limestone thrust over the Sawtooth Formation of Jurassic age.

Table of Contents

Viewing Stereo Images	0
Strike & Dip	1
Parts of Folds	2
Axis and Axial Plane of Asymmetric Plunging Fold	3
Mechanics of Folding	4
Introduction to Folds	5,6
Outcrop Patterns of Folds	7
Monocline	8,9
Dome	10
Anticline	11
Asymmetric Plunging Folds	12,13
Structural Saddle on Alkalai Anticline	14
Stretch Fault Cuts Flank of Alkalai Anticline	15
Big Sheep Mountain, Lower Level of a Concentrically Folded Anticline	16
Elk Basin, Upper Level of a Concentrically Folded Anticline	17
Asymmetric Anticline	18
Folds with Overturned Flanks	19
Folds with Horizontal Axes, Pennsylvania	20
Oppositely Plunging Folds	21
Little Dome, an Asymmetric Doubly Plunging Anticline	22
Asymmetric Plunging Nose	23
Drag Folds with Boudinage in Flanks	24

Folds with Both Concentric and Similar Characteristics -----	25
Isoclinal Fold, Chickaloon Pass -----	26
Foster Creek Nappes -----	27
Rock Creek Nappe -----	28,29
Complex Overturned Syncline -----	30
Isoclinal Refolded Fold -----	31
Simplified Geologic Map of the Riverside Mountains -----	32
Extreme Thinning of Overturned Flank -----	33
Soft Sediment Folds -----	34
Extreme Soft Sediment Folds -----	35
Crumpled Axial Area -----	36
Disharmonic Folds of the Besa River Formation -----	37
Disharmonic Folds at Sandy Hollow -----	38
Decollement at Base of Disharmonic Folds -----	39
Similar Folds in Gneiss -----	40
Foliation and Lineation -----	41
Refolded Fold -----	42
Ptygmatic Folds -----	43
Tongue-like Folds in Welded Tuff -----	44,45
Isoclinal Fold in Volcanic Tuffs -----	back cover

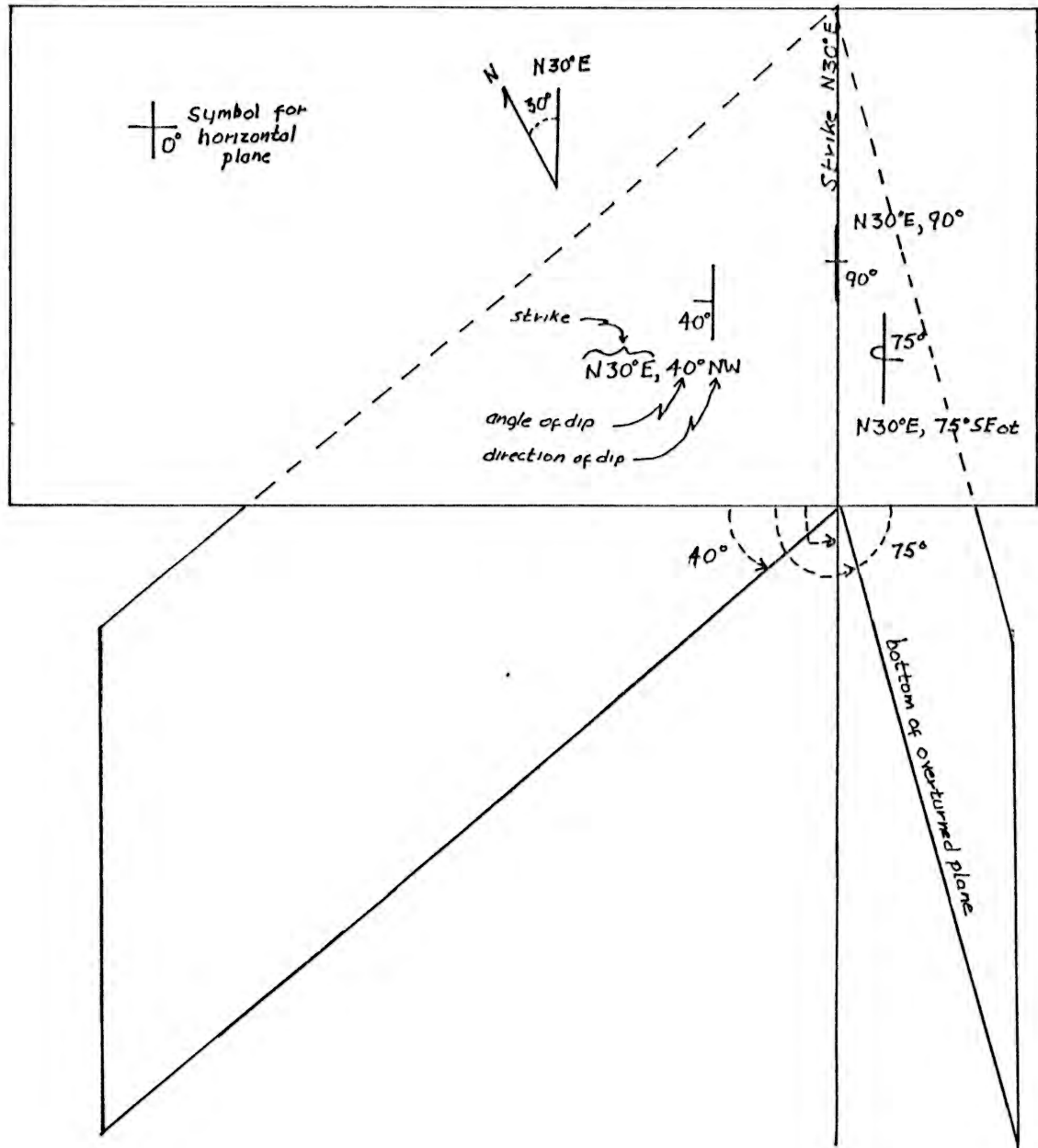
Viewing Stereo Images

The two small pictures at the top of each page are a stereo pair. To see the image in three dimensions, you need to look at the right image with the right eye and the left image with the left eye. To do this, pick out some prominent feature in the pictures and stare beyond the pictures. The two prominent features, one from each picture, should float together in the center. This center image will be in three dimensions. At first it may not be in focus. You are accustomed to associate convergence of your eyes with focus. If you continue to stare at the center image, your mind will ultimately relent and focus on the center image while your gaze remains parallel, each eye looking at its respective image.

A simple exercise may help prepare you for this unaccustomed way of viewing. With your hands at arm's length in front of your eyes, touch your two index fingers together as you look beyond them. You should see a sausage image between your two index fingers. Your eyes are parallel, the right one looking at the right finger, the left one at the left finger. The two images have floated apart, the right one to the left and the left one to the right to form the sausage. The feeling in your eyes is the one you should try to imitate when looking at the stereo images. Some will master the technique instantly. It will take longer for others. If you don't succeed at first, keep trying at odd times. Try sometime when you are really tired and tend to see double images anyway when you stare at objects. If I could learn to do it, anyone with two good eyes can. I worked at it off and on for over two years before I suddenly learned the knack.

Your eyes are just a few inches apart. With that small separation, you can see in three dimensions for about 1100 feet. Most of these images were taken from a small airplane flying at a velocity of about 100 mph. The interval between the two images varied from one second to several seconds, giving an effective eye base of between 100 and several hundred feet. With this eyebase, you can see in three dimensions for miles. These pictures produce spectacular three dimensional views not easily obtainable in any other way.

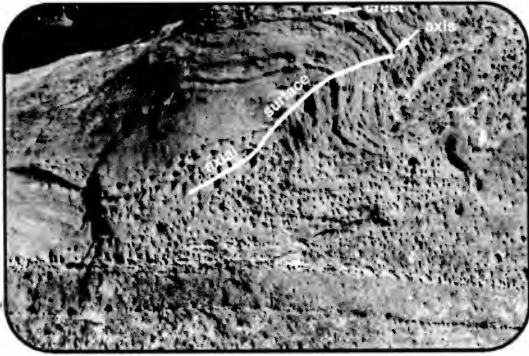
Strike & Dip



strike = compass bearing of a horizontal line on the surface of a plane

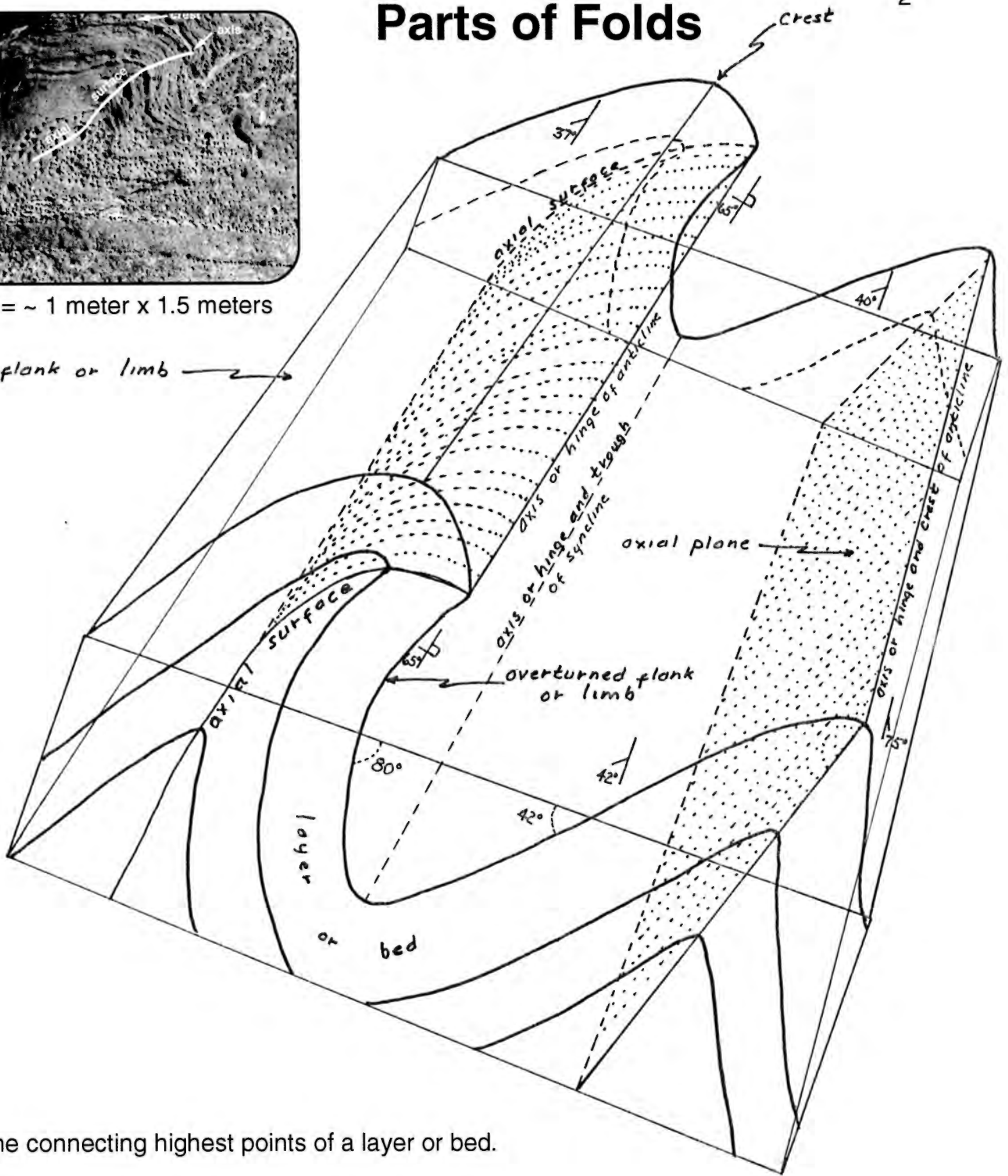
dip = angle and direction in which a plane is inclined downward, measured from the horizontal

Parts of Folds



outcrop = ~ 1 meter x 1.5 meters

upright flank or limb →



crest = line connecting highest points of a layer or bed.

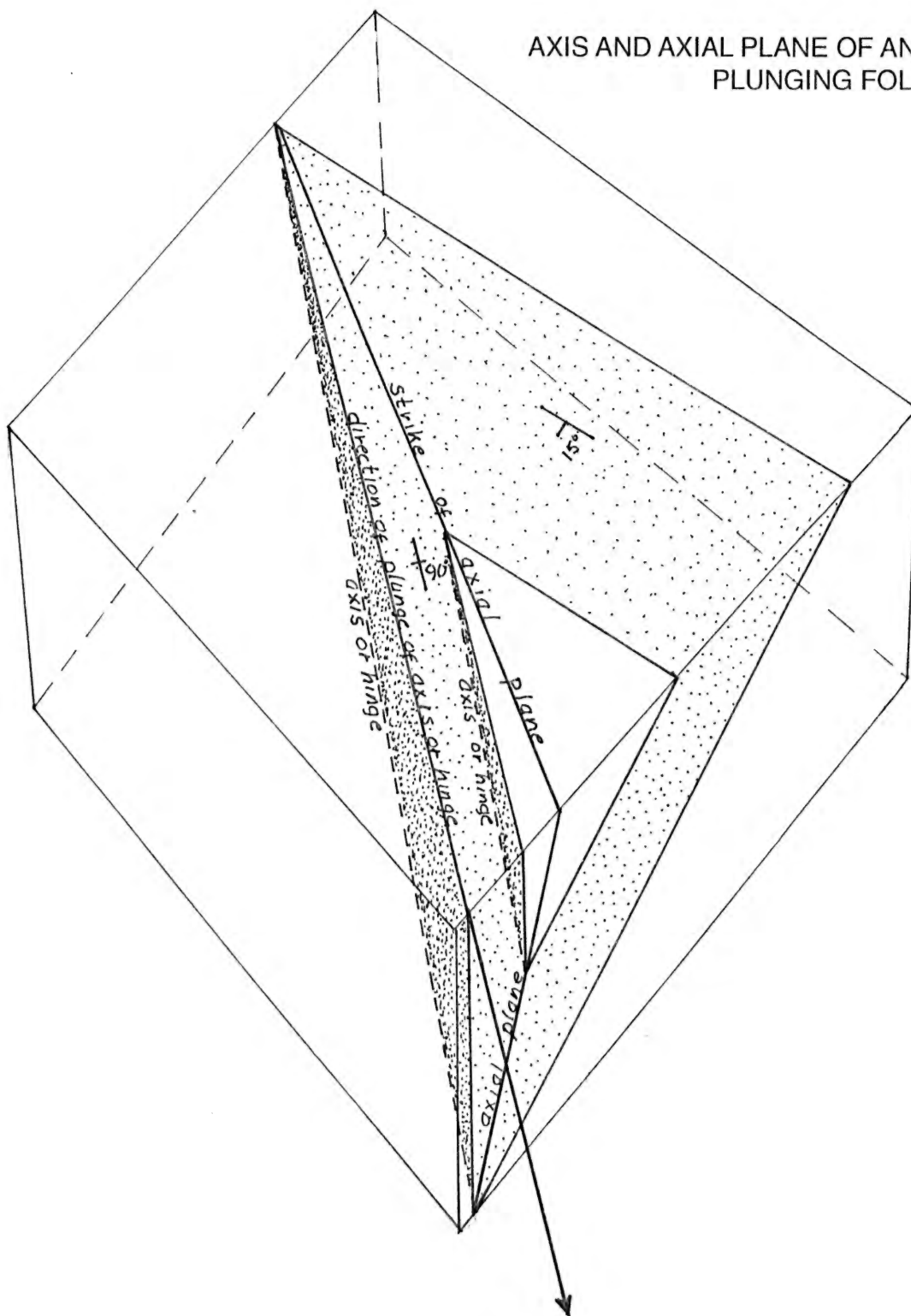
trough = line connecting lowest points of a layer or bed.

axis or hinge = line along maximum bend of a layer or bed.

axial plane or surface = plane or surface that connects the axes of successive layers.

anticline = convex-upward fold syncline = concave-upward fold

AXIS AND AXIAL PLANE OF AN ASYMMETRIC, PLUNGING FOLD

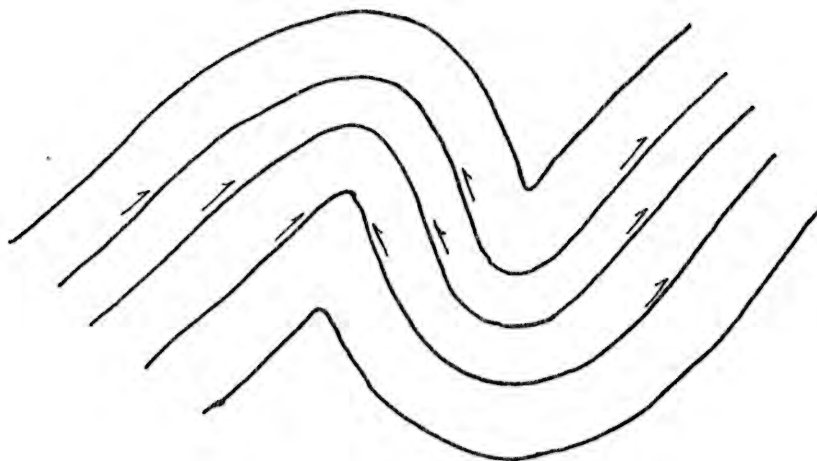


As shown in the diagram above, in a fold that has an inclined axis and an inclined axial plane, the strike of the axial plane will diverge from the direction of plunge of the axis.

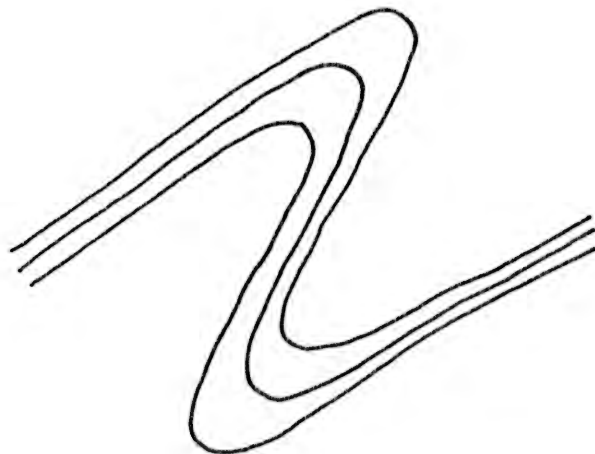
Mechanics of Folding

Two types of folds, concentric folds and similar folds, are shown below.
Many folds contain elements of both concentric and similar folding.

In concentric folds the beds are stiff, they maintain their thicknesses, and they control the development of the fold, which must change shape from top to bottom. The anticlines are broad and rounded toward the top of the fold and become sharp and angular downward. The synclines are sharp and angular toward the top of the fold and become broad and rounded downward. As shown by the arrows, the beds must slide over one another during the folding process.



In similar folds the layers behave passively and change in thickness while the shape of the fold remains constant from top to bottom. Material in the layers flows from the flanks into the axial areas of the fold. Similar folds develop in rocks that are either intrinsically weak and plastic or become weak and plastic when they are exposed to high temperatures and pressures.



Introduction to Folds

Types of Rocks:

Almost any type of rock may be folded, but massive rocks without layers are difficult to fold, and because there are no layers, the folds may not be visible. Folds are more easily seen in layered rocks, and layered rocks are more easily folded because folding is facilitated by slippage between layers and by plastic flow of easily deformed layers.

Causes:

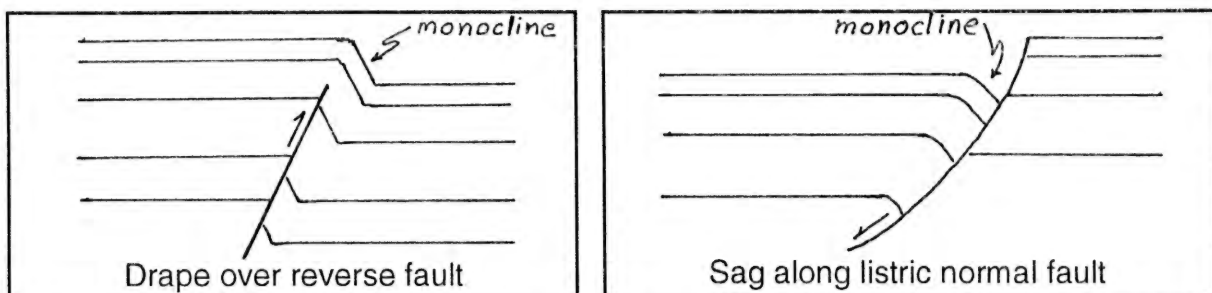
Folds may be produced by compression where crustal plates collide and by compression generated by shear as plates slide past one another on transform faults. In addition, folds may also be produced as rocks, propelled by gravity alone, slide off elevated areas into basins. Folds may also be produced where intrusions of salt or magma (molten rock) distort the rocks above and around them.

Folds produced by compression tend to occur in swarms that have nearly parallel orientations of their axes and axial planes which, in turn, are approximately perpendicular to the compressive stress. Folds generated in the upper parts of the crust tend to be concentric. Those generated in the lower crust, under higher temperatures and pressures, tend to be similar. At deeper levels in the crust new minerals form under the heat, pressure and strain. Platy minerals are aligned with their flat surfaces perpendicular to the pressure and parallel to shear. Other minerals are segregated into bands as the rocks flow plastically. The layering thus produced is called foliation. The foliation may be folded and then refolded as the rocks flow plastically in response to plate motions. At upper levels in the crust, folding is accompanied by fracturing of the rocks and sliding along the fractures (faulting). Folding and faulting may alternate or occur simultaneously.

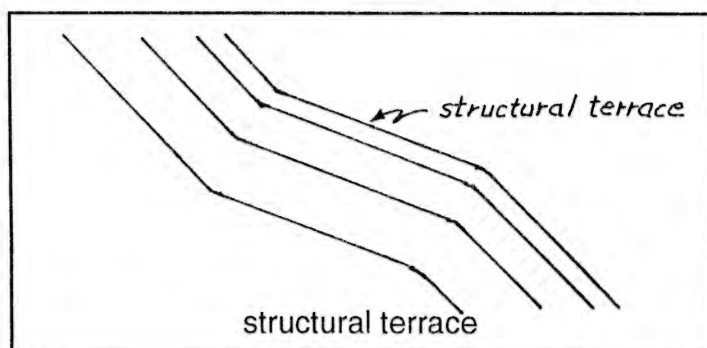
Folds of all sizes up to mountain-range size may occur as rocks slide off elevated areas into foredeep basins. The rocks may have been elevated by collision between plates, by intrusion of large masses of molten rock, or by both working together. The orientations of these folds tend to be more varied because directions of sliding change as different parts of the mountains and basins rise and sag. Most of these folds have overturned limbs and many have nearly horizontal or gently inclined axes and axial planes. They may develop the way a stack of rugs would fold if it slid down a slope, its leading edge slowed as it hit the base of the slope, and its trailing parts rolled over its toe. Large folds of this sort occur in the Alps. They are called "nappes", the French word for sheets, and they tend to pile up, one on top of another or adjacent to each other, until the foredeep basin is filled. Gravity also produces folds in soft sediments deposited on underwater slopes.

Types of Folds:

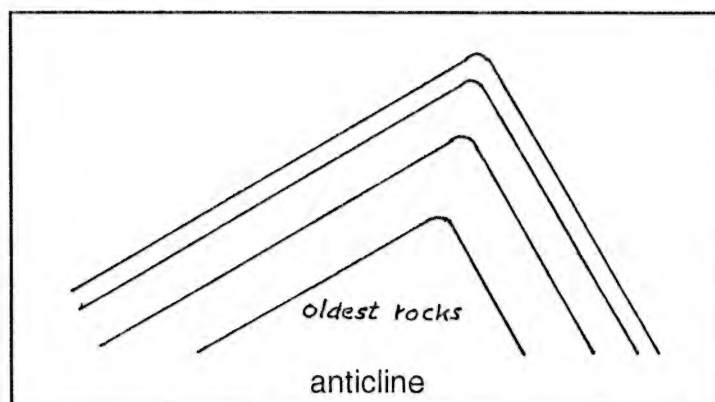
A monocline is an interruption of homoclinal dip by an area of steeper dip. Monoclines may develop as drape over reverse faults or as sags along listric (concave-upward) normal faults.



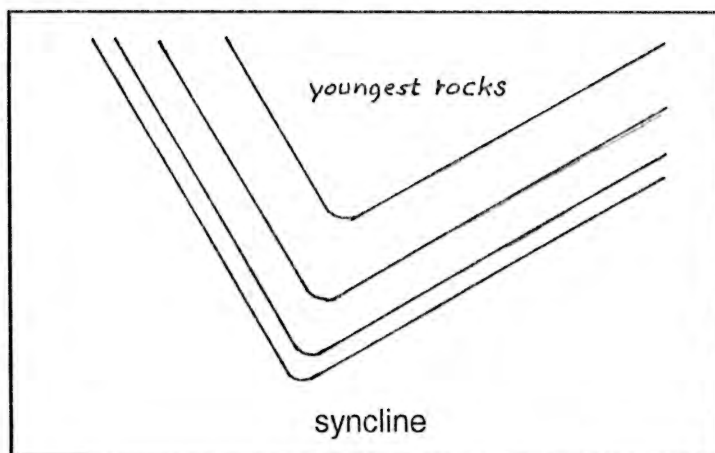
A structural terrace is an interruption of a homoclinal dip by an area of gentler dip



An anticline is a convex-upward fold.



A syncline is a concave-upward fold.



The terms antiform and synform are used for convex-upward and concave-upward folds in metamorphic rocks where the orientations of the original folds cannot be determined. The original anticlines and synclines may have been turned upside down.

TEXT FOR OUTCROP DIAGRAMS

A

Folds that have horizontal axes and vertical axial planes are symmetrical. That is, the axial plane is a plane of symmetry; one flank is a mirror image of the other. The outcrop widths of the beds in opposite flanks are equal, and the strikes of the flanks are parallel, producing a series of linear, parallel ridges and swales as erosion exploits the weaker beds. Oldest beds outcrop in the centers of anticlines and youngest beds in the centers of synclines.

B

Folds that have horizontal axes and inclined axial planes are asymmetrical. One flank is steeper than the other, and the outcrop widths of beds in opposite flanks are not equal. The steeper flank has narrower outcrop widths. The strikes of the flanks are parallel, and erosion produces a series of linear, parallel ridges and swales. Oldest beds outcrop in the centers of anticlines and youngest beds in the centers of synclines.

C

Folds that have inclined axes and vertical axial planes are symmetrical and form a zig-zag pattern of ridges and swales. The strikes of the flanks converge in the direction of plunge of anticlinal axes and diverge in the direction of plunge of synclinal axes. The outcrop widths of beds in opposite flanks are equal. Oldest beds outcrop in the centers of anticlines and youngest beds in the centers of synclines. The strike of the axial plane is the same as the plunge direction of the axis.

D

Folds that have inclined axes and inclined axial planes are asymmetrical. The outcrop widths on the steep flank are narrower than those on the gentle flank. Erosion forms a zig-zag pattern of ridges and swales. The strikes of the flanks converge in the direction of plunge of anticlinal axes and diverge in the direction of plunge of synclinal axes. Oldest beds outcrop in the centers of anticlines and youngest beds in the centers of synclines. The strike of the axial plane is not the same as the plunge direction of the axis.

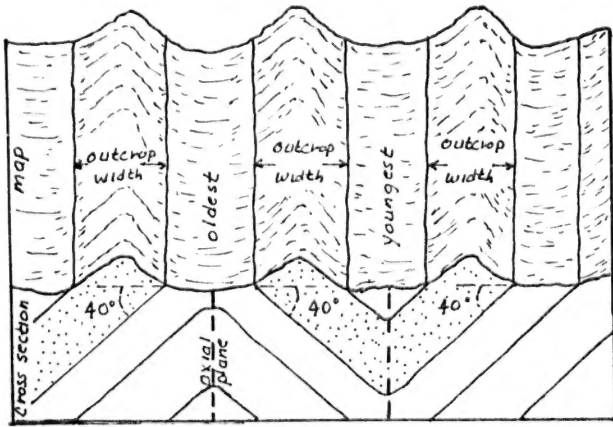
E

Folds that have vertical axes and vertical axial planes are symmetrical and isoclinal. That is, opposite flanks have the same dip; they are vertical. Outcrop widths of beds on opposite flanks are the same and, because the beds are vertical, are equal to the true thicknesses of the beds. Oldest beds outcrop in the centers of anticlines and youngest beds in the centers of synclines. Erosion carves a zig-zag pattern of ridges and swales.

F

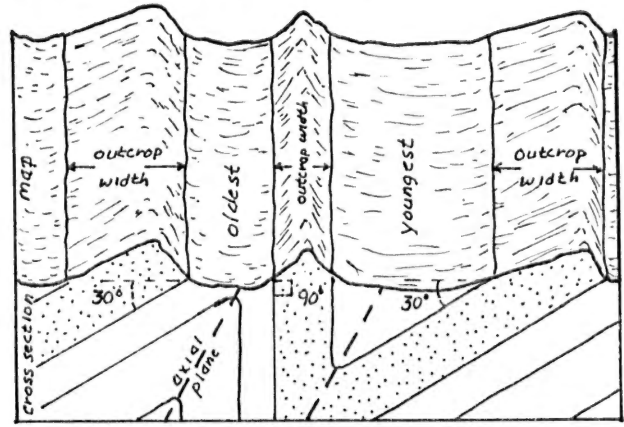
Folds that have horizontal axes and horizontal axial planes are recumbent. They may outcrop as a series of uniformly (homoclinally) dipping beds, as shown in the diagram. A cross sectional view is then needed to determine if the beds are indeed folded as shown. A variety of other outcrop patterns are possible, depending upon how the ground surface intersects the flanks of the recumbent folds.

Outcrop Patterns of Folds



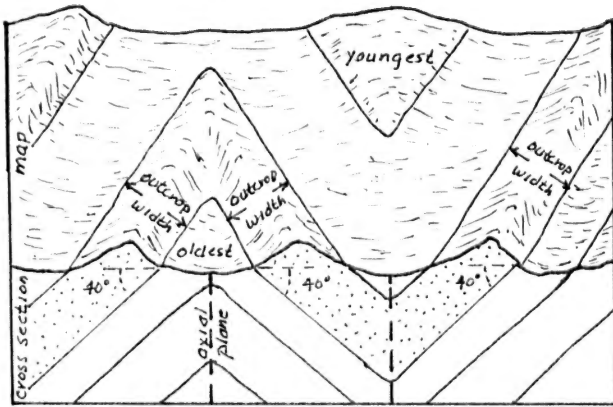
A

Horizontal Axis & Vertical Axial Plane



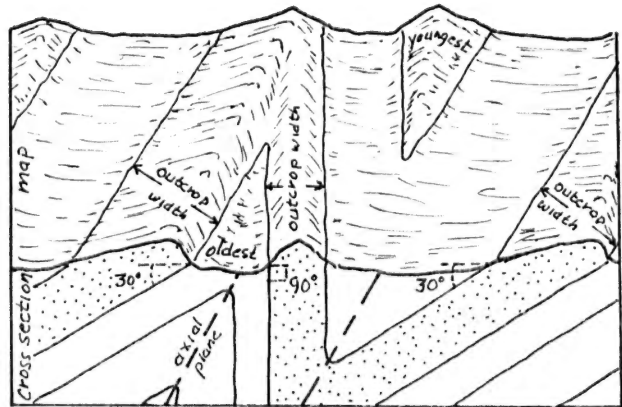
B

Horizontal Axis & Inclined Axial Plane



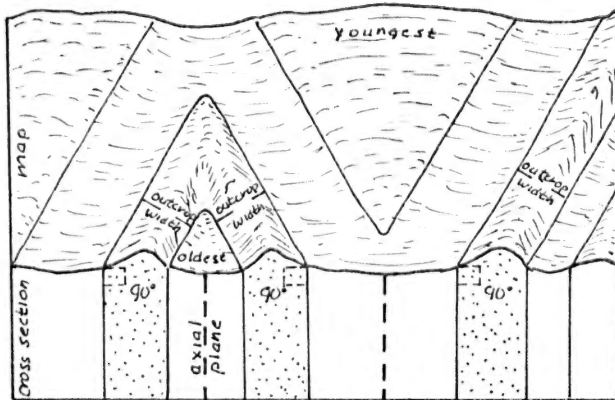
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Inclined Axis & Vertical Axial Plane



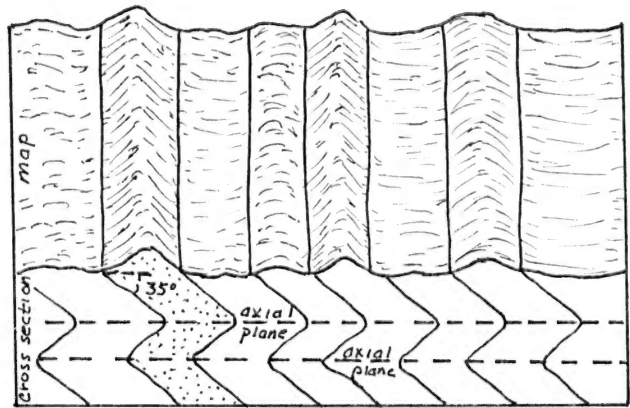
D

Inclined Axis & Inclined Axial Plane



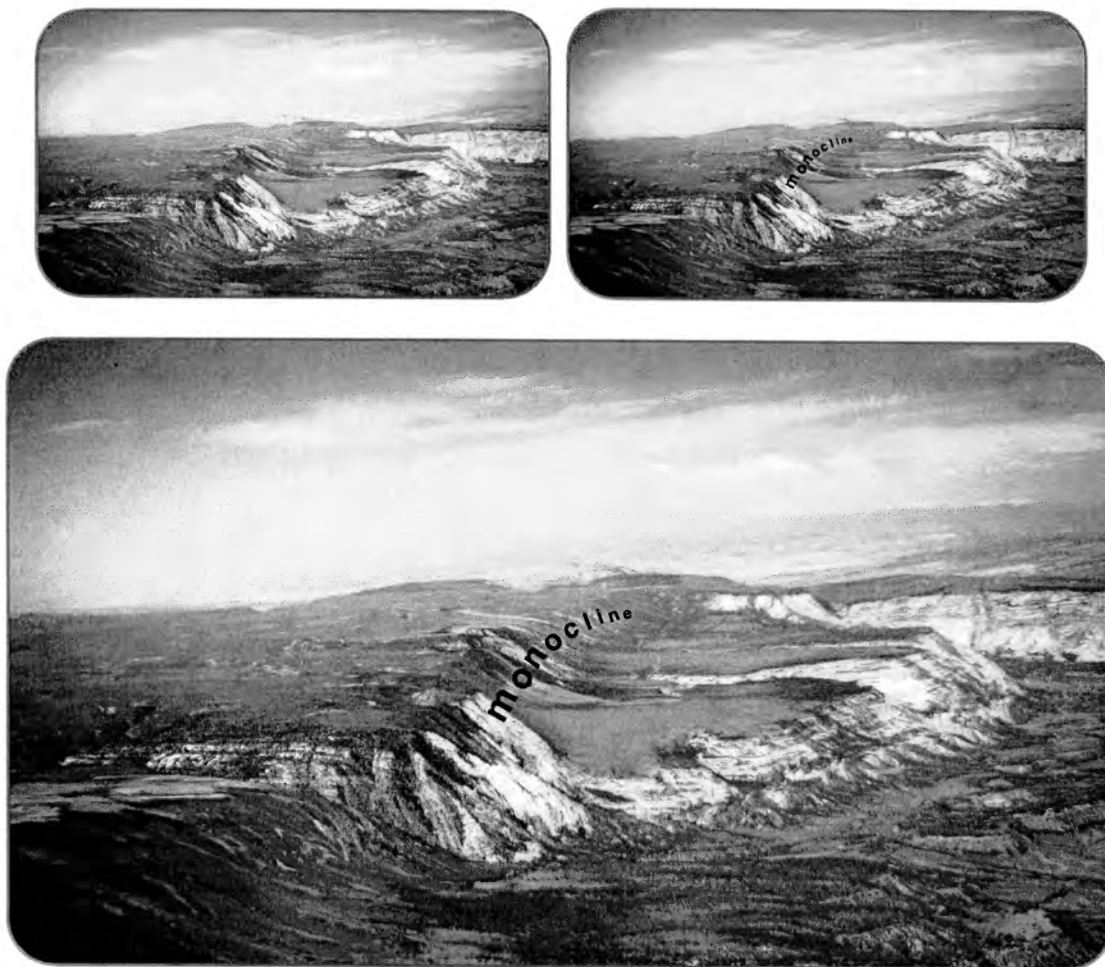
E

Vertical Axis & Vertical Axial Plane



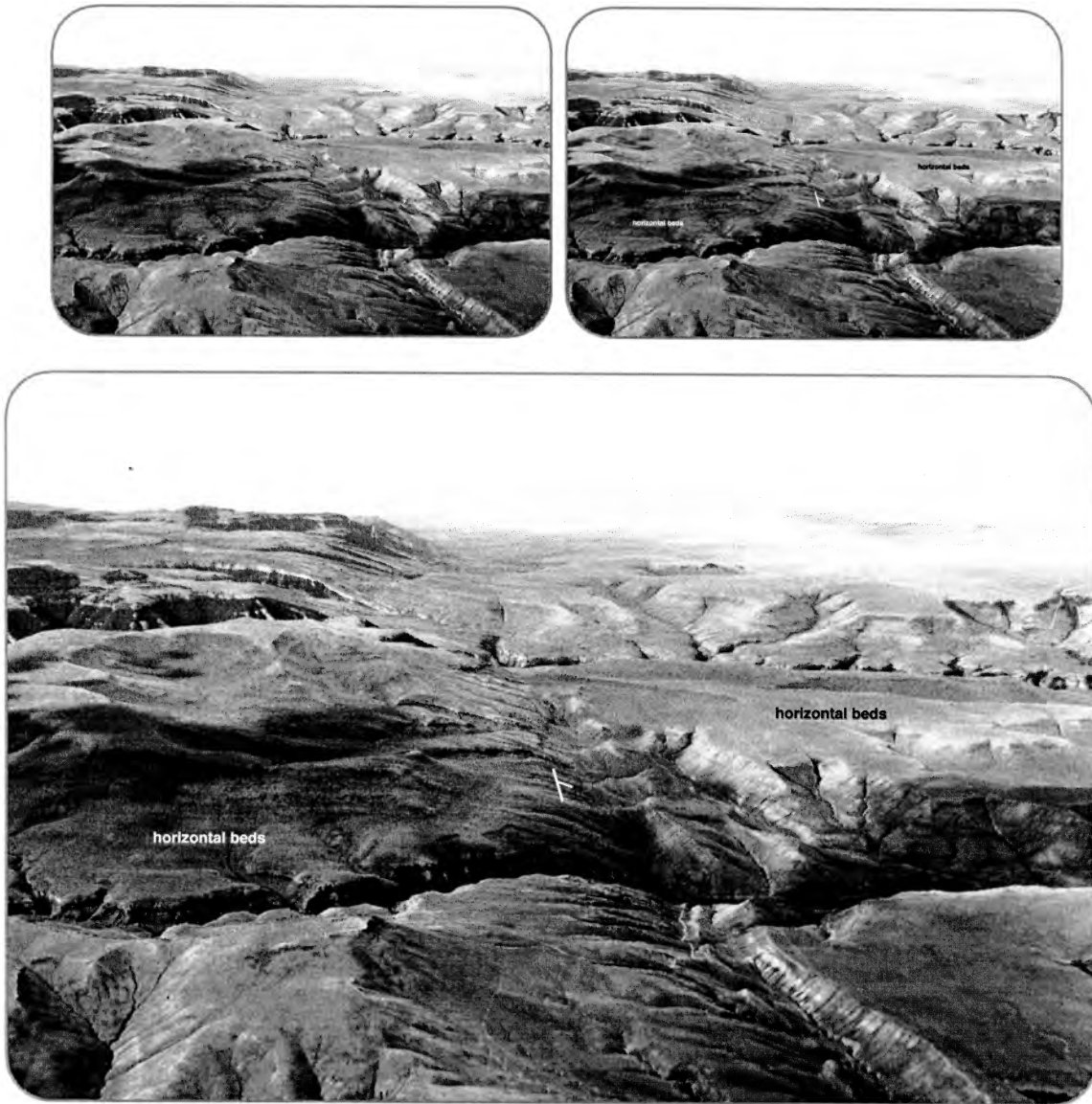
F

Horizontal Axis & Horizontal Axial Plane



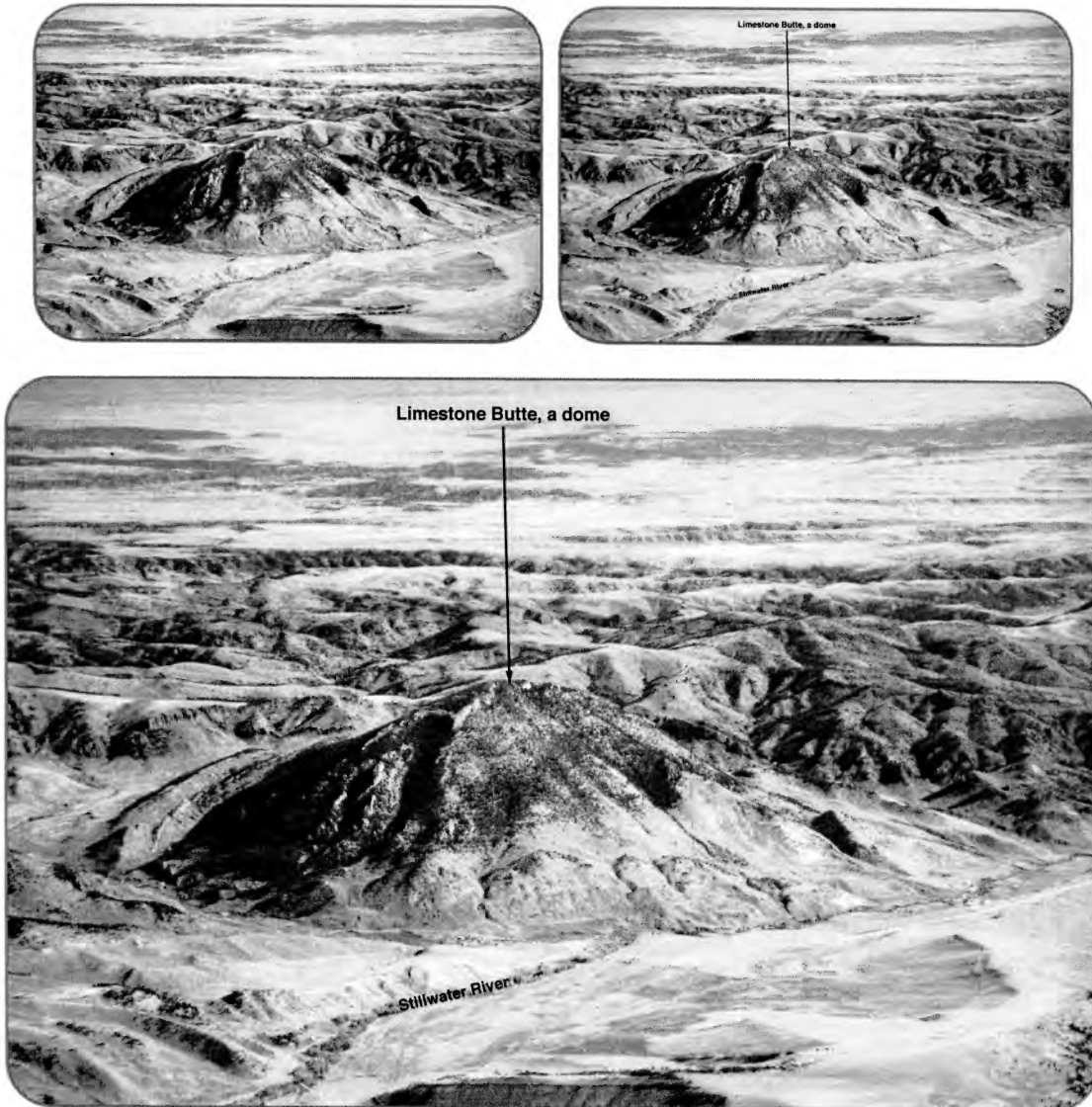
Monocline

You are looking westward at a monocline in northwestern Colorado. Steeper dip interrupts an area of gentler dip to form the single limb of the monocline. Monoclines are long linear folds, each usually underlain by a reverse fault that pushed the overlying beds up, forcing them to drape over the fault.



Monocline

You are looking southward along a monocline, probably draped over a reverse fault, in the Pryor Mountains of south-central Montana. Picture taken August 8, 1985.



Dome

You are looking toward the northeast at Limestone Butte along the Stillwater River in the foothills of the Beartooth Mountains of Montana. The butte is a dome, probably arched above a laccolith which formed as molten rock squeezed with the shape of a mushroom into the overlying rocks. The molten rock cooled and crystallized beneath the circular uplift. The beds dip away from its center and change strike continually around it, so the fold lacks a well defined hinge.



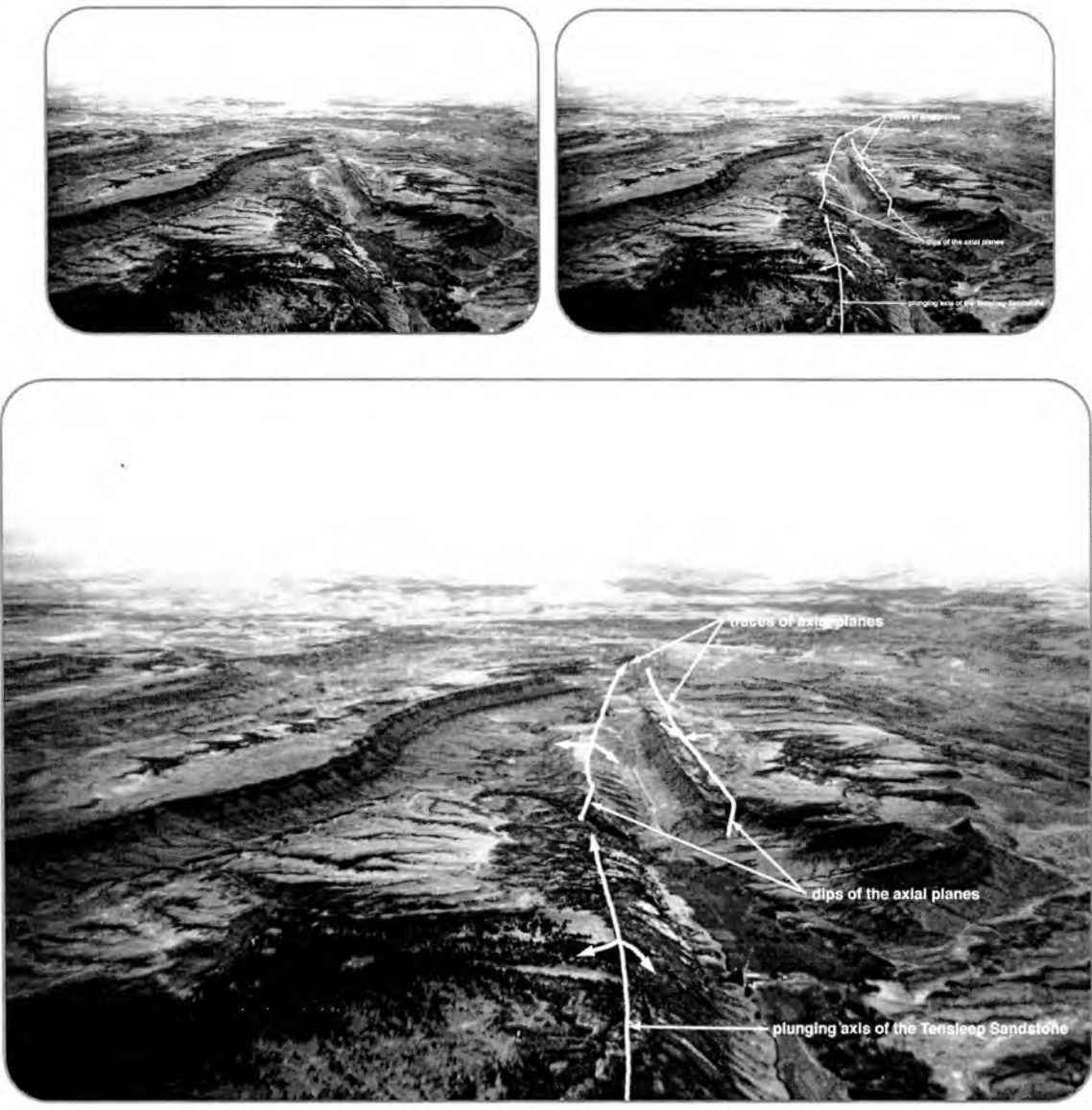
Anticline

You are looking northeastward at a small anticline in the Triassic Dinwoody Limestone just north of Sandy Hollow in southwestern Montana. The anticline formed along the Sandy Hollow thrust as the Dinwoody overrode the Gastropod Limestone at the top of the Cretaceous Kootenai Formation. The axis on one bed is followed by a line on the picture. The rocks in the right hand portion of the axial area were dragged into an "S" fold as the beds above slid over them (black arrow). Beds on both flanks of the fold tend to slide toward the crest as the rocks fold, generating space in the axial area. In this instance that space was taken up by the "S" fold.



Asymmetric Plunging Folds

You are looking southward at asymmetrical, plunging folds along the eastern side of the Big Horn Mountains west of Kaycee in Wyoming. The lines follow the traces of the axial planes as they intersect the ground surface. The plunges of the fold axes are shown by arrows along the traces of the axial planes. Directions of dip are indicated for the axial planes in the lower part of the picture.



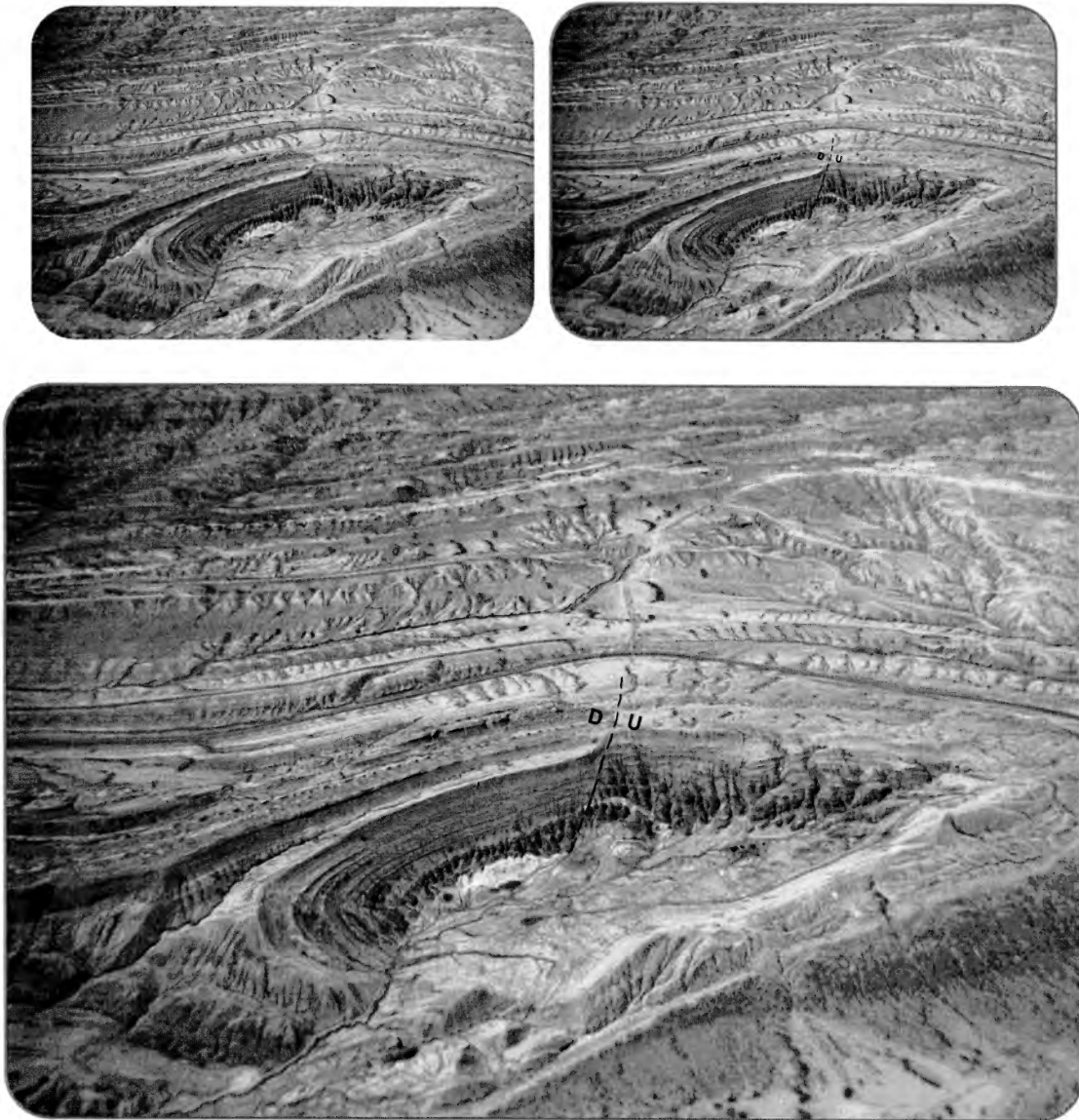
Asymmetric Plunging Folds

You are looking southward at an asymmetrical anticline and syncline folded along the eastern side of the Big Horn Mountains west of Kaycee, Wyoming.



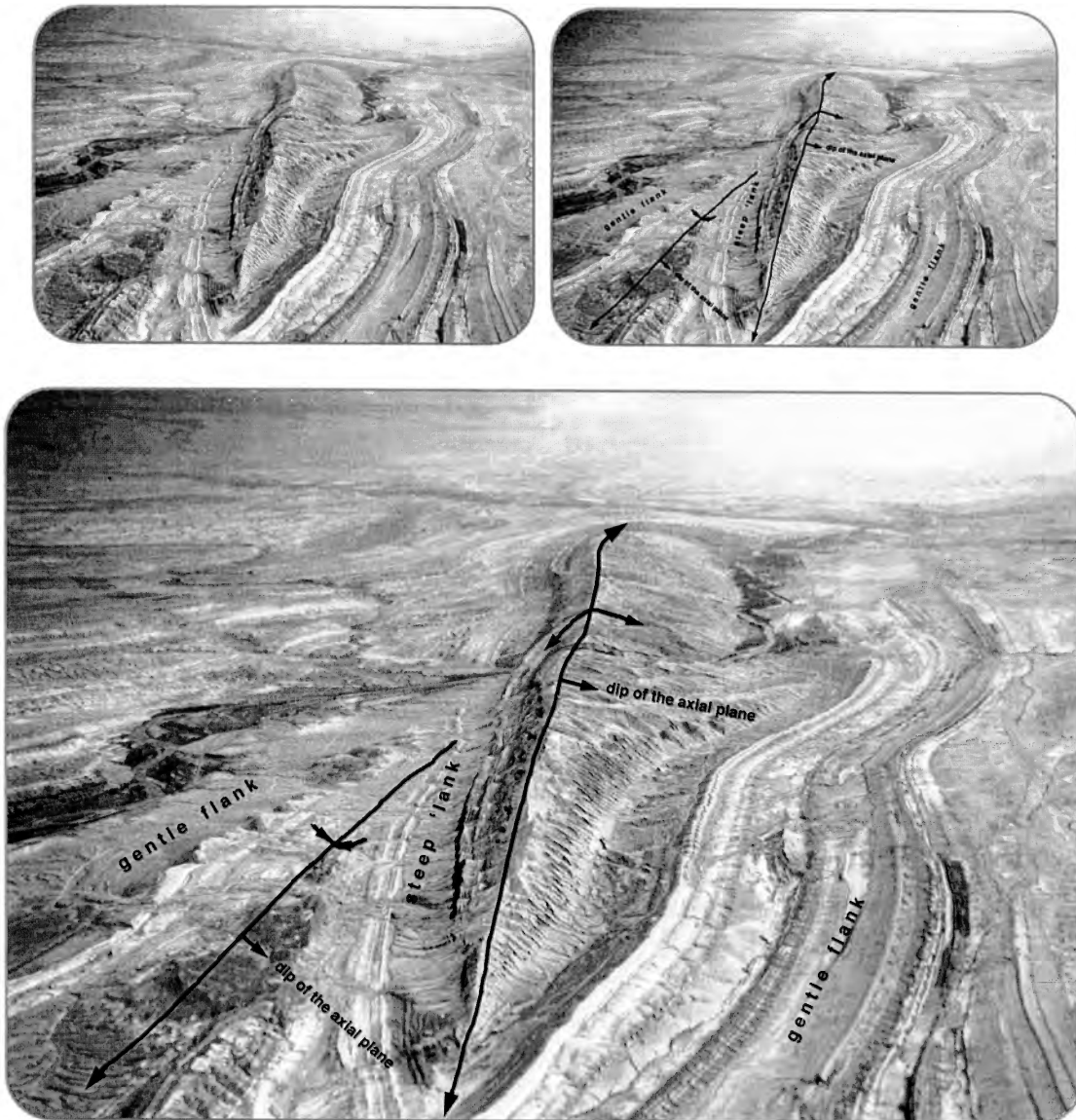
Structural Saddle on Alkalai Anticline

You are looking southward at Alkalai Anticline, a nearly symmetrical structure, in the eastern Big Horn Basin of Wyoming. The structure has two closures separated by a saddle. The solid lines follow the traces of the axial planes as they intersect the ground surface. The arrows along the traces indicate the directions of plunge of the axes. Of the double-headed arrows that cross the traces of the axial planes, those that point toward the traces indicate synclines; those that point away from the traces indicate anticlines. The dashed line follows a small fault caused by stretching the Lower Cretaceous beds over the growing fold core.



Stretch Fault Cuts Flank of Alkalai Anticline

You are looking westward at the normal fault that cuts the western flank of the northern closure on Alkalai Anticline in the Eastern Big Horn Basin of Wyoming. As the competent core of the fold grew upward and lengthwise, these overlying incompetent Lower Cretaceous beds stretched and faulted.



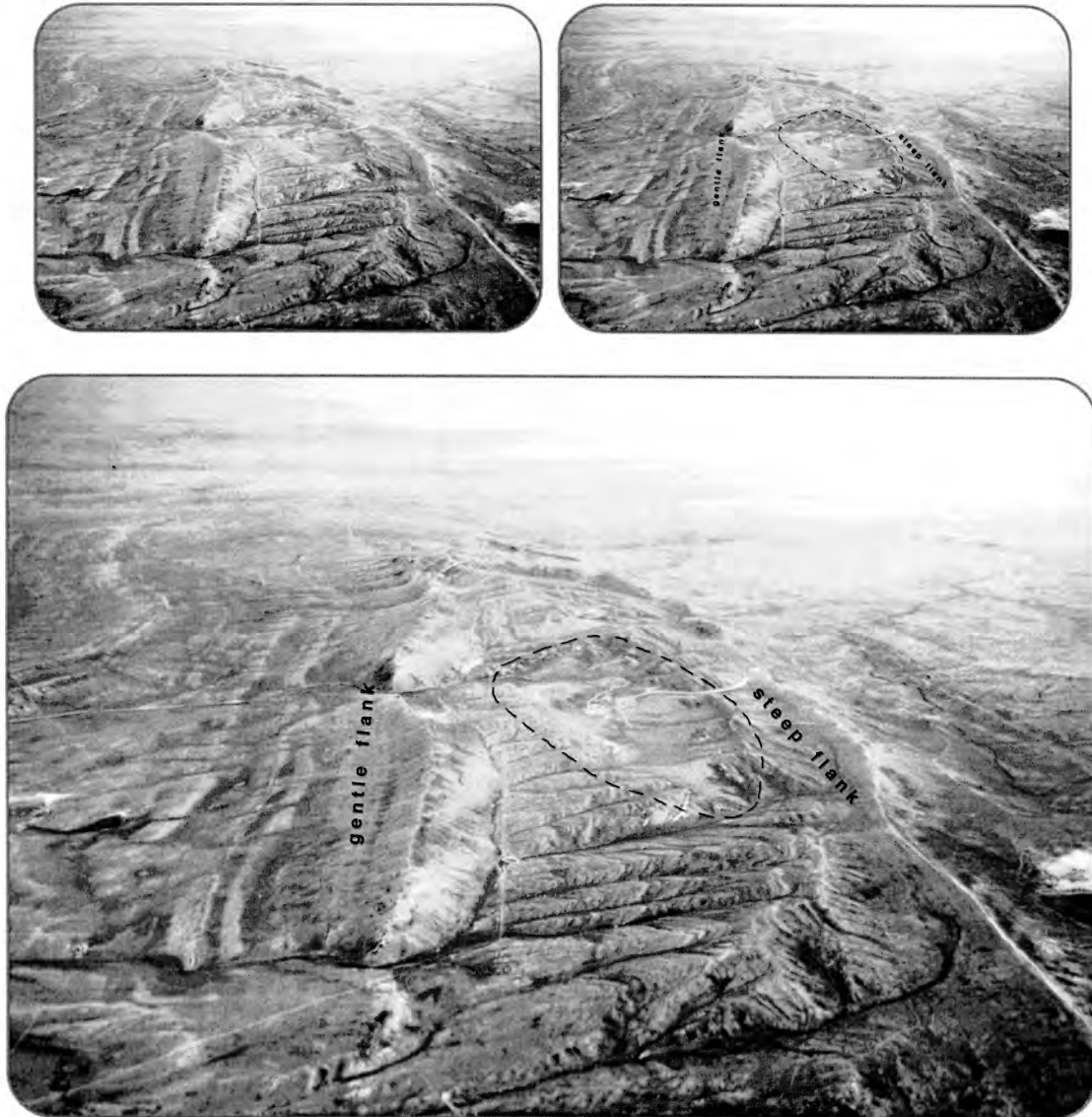
Big Sheep Mountain, Lower Level of a Concentrically Folded Anticline

You are looking toward the south along the axis of Big Sheep Mountain Anticline in the eastern Big Horn Basin of Wyoming. It is a doubly plunging asymmetrical anticline whose axial plane dips steeply toward the west.



Elk Basin, Upper Level of a Concentrically Folded Anticline

You are looking toward the north at Elk Basin Anticline in the northern Big Horn Basin of Wyoming and Montana. Elk Basin is a large doubly plunging anticline that produces oil from numerous horizons ranging in age from Mississippian to Cretaceous. The dashed lines show just three of the many stretch normal faults developed in the Upper Cretaceous Mesaverde Formation over the top of the anticline.



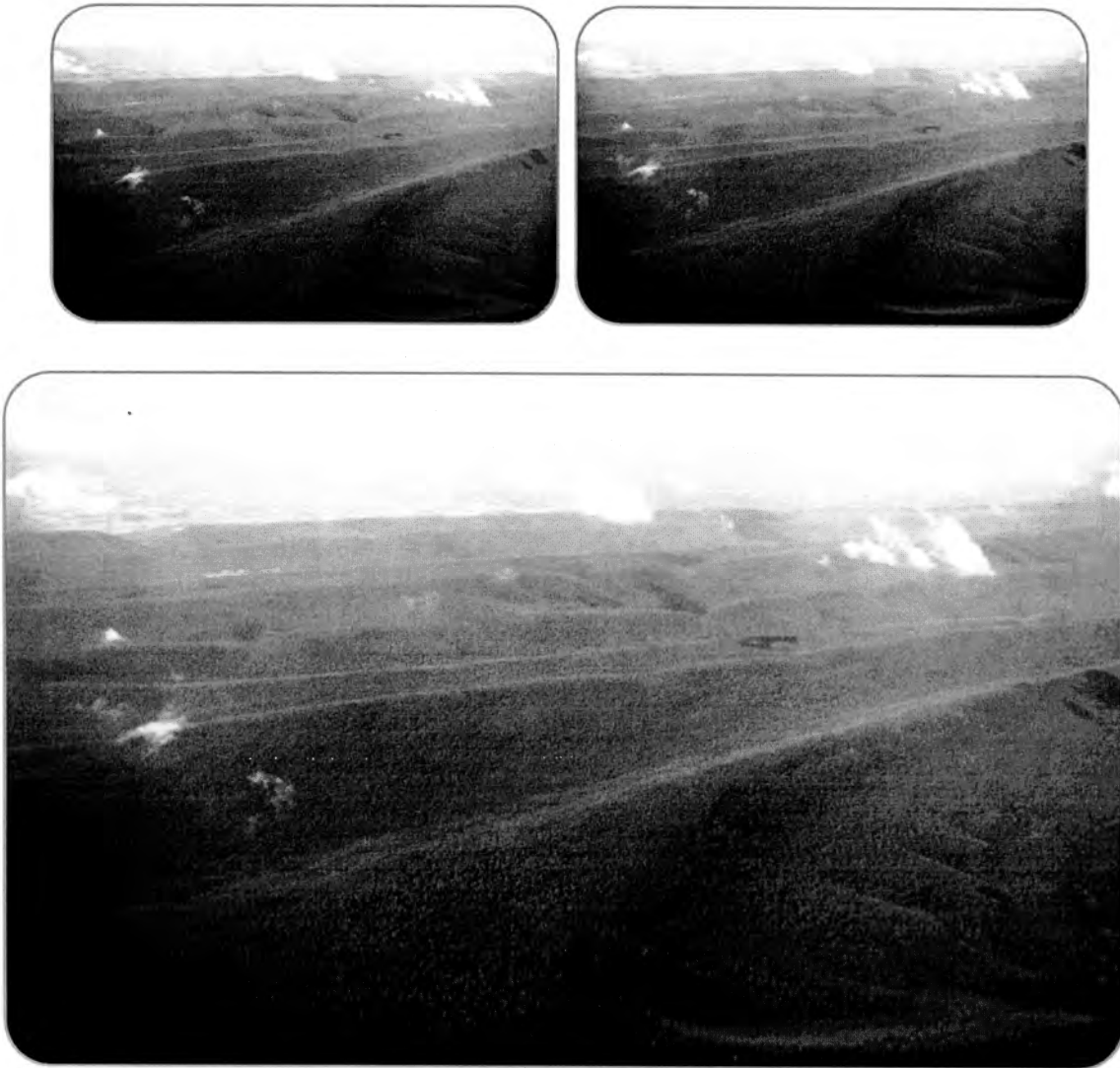
Asymmetric Anticline

You are looking toward the northeast at an anticline just north of Elk Mountain in south-central Wyoming. The dashed line outlines a small area of closure on this otherwise northeast plunging asymmetrical structure. Wells located within this area of closure at the surface will encounter the steep flank of the anticline at depth because the axial plane dips toward the gentle flank of the structure.



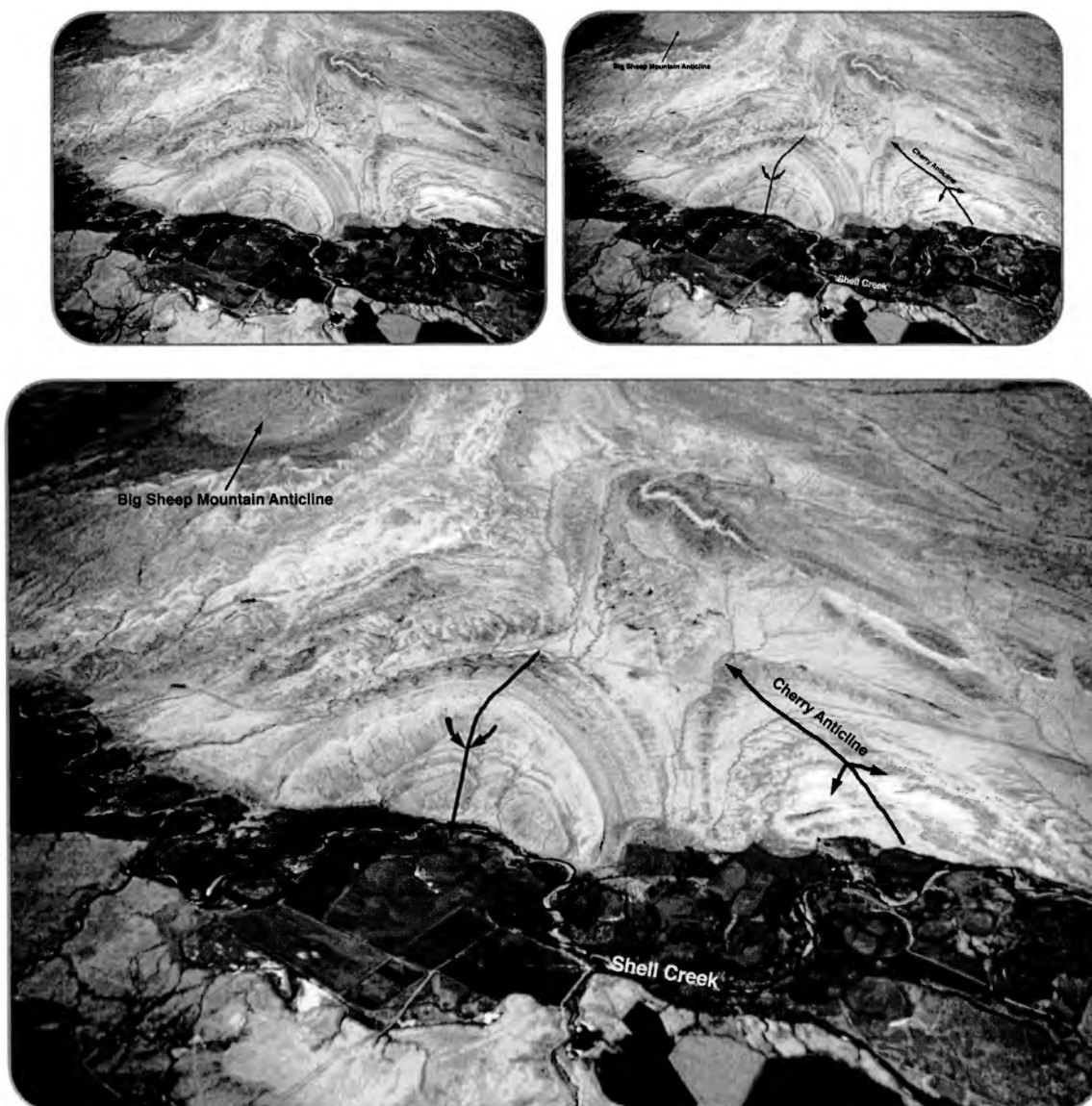
Folds with Overturned Flanks

You are looking northward along the eastern side of the Pioneer Mountains in southwestern Montana. The southeastern flanks of the anticlines are also the northwestern flanks of intervening synclines. They are overturned. The axial planes dip northwestward.



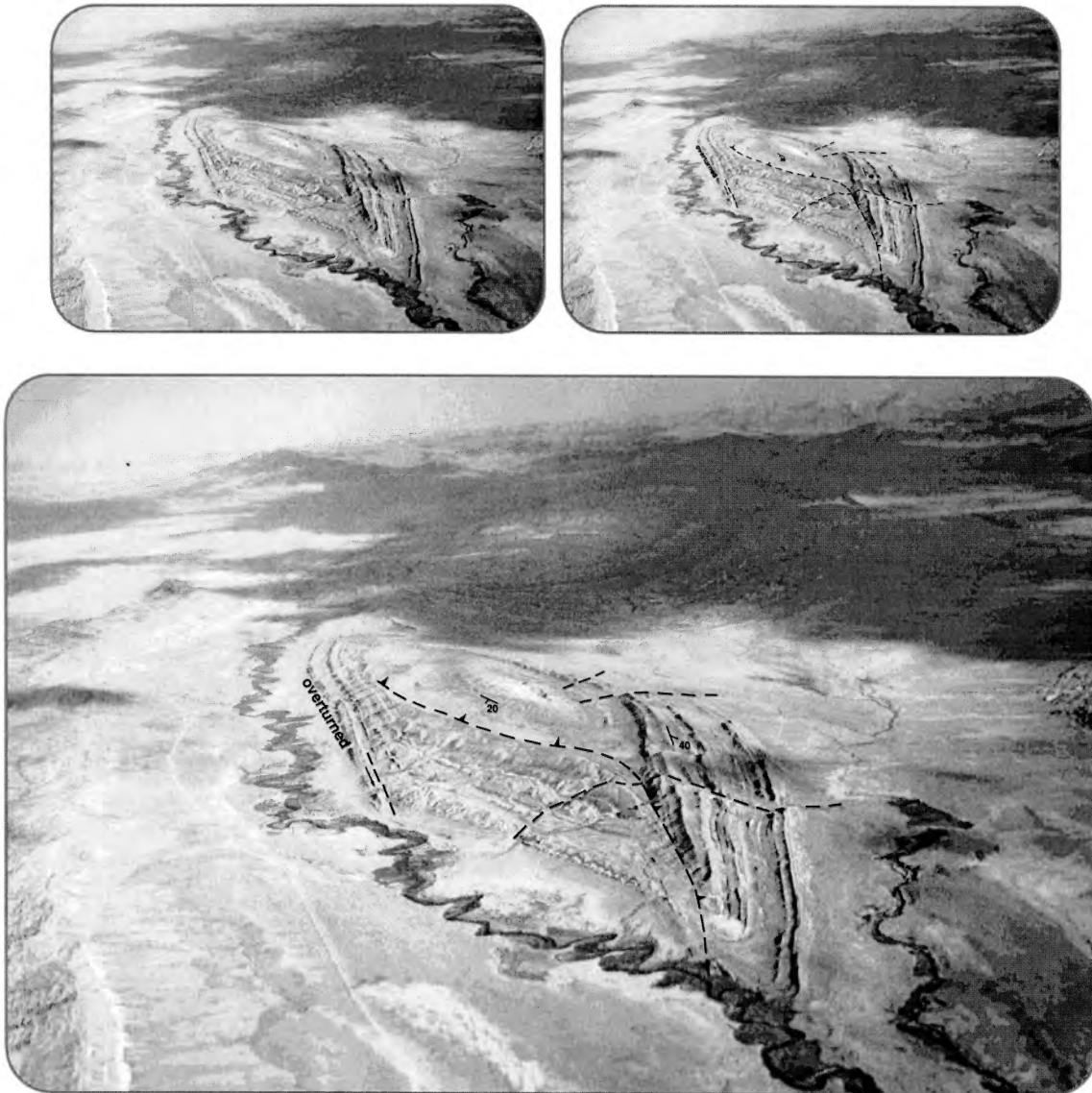
Folds with Horizontal Axes, Pennsylvania

You are looking southward across the Ridge and Valley Fold Province in central Pennsylvania. The ridges are supported by the Silurian Tuscarora Quartzite. The valleys are carved on Ordovician limestones and shales. Most of the ridges follow the nearly horizontal axes of the synclines, while the valleys follow the axes of the anticlines. In the lower right corner an anticline plunges northeastward.



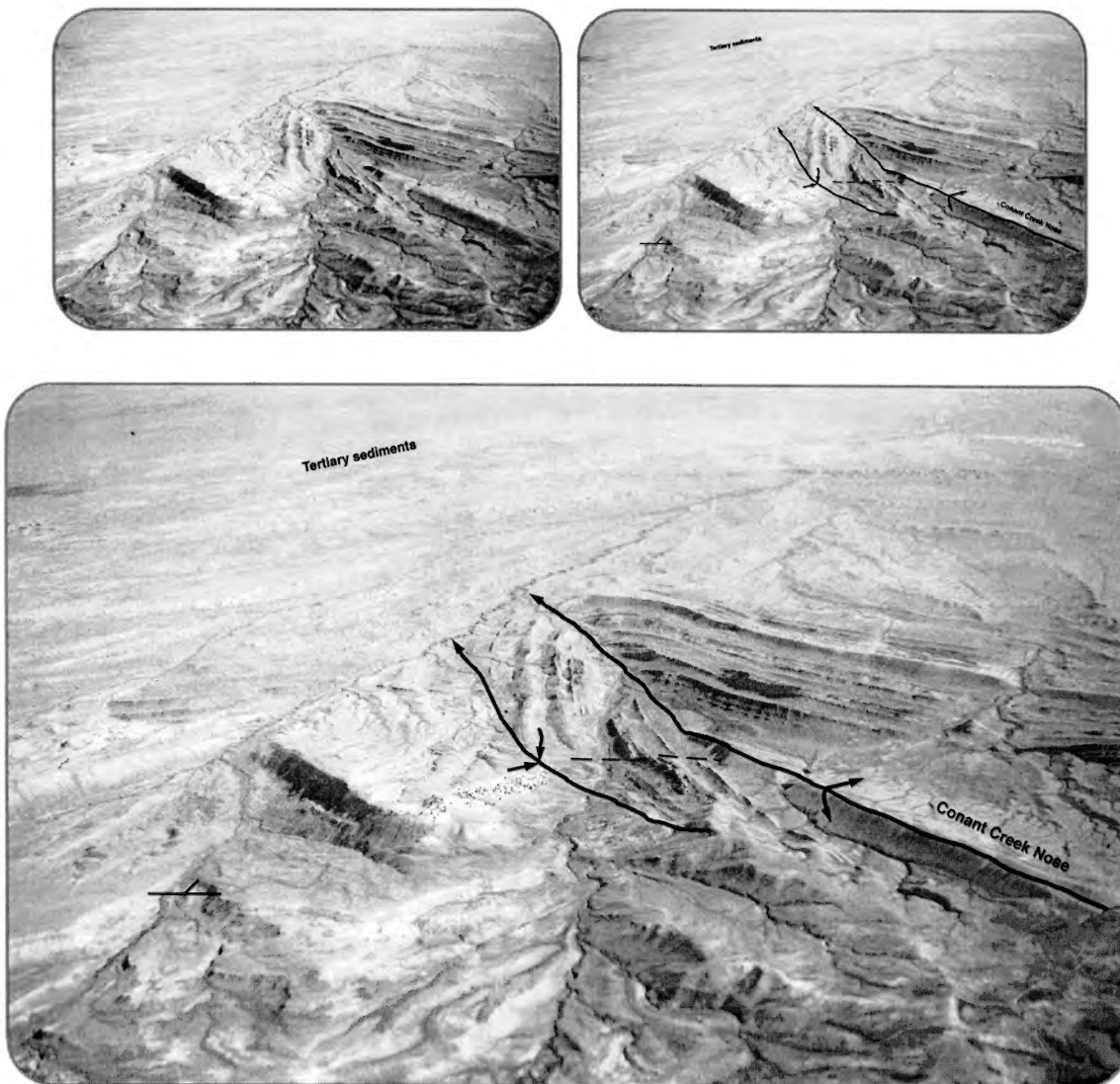
Oppositely Plunging Folds

You are looking toward the north across Shell Creek at Cherry Anticline and its adjacent syncline in the eastern Big Horn Basin just east of Greybull, Wyoming. Instead of the usual zig-zag outcrop pattern that forms across synclines and anticlines that plunge in the same direction, this odd outcrop pattern results from plunges that are nearly opposite.



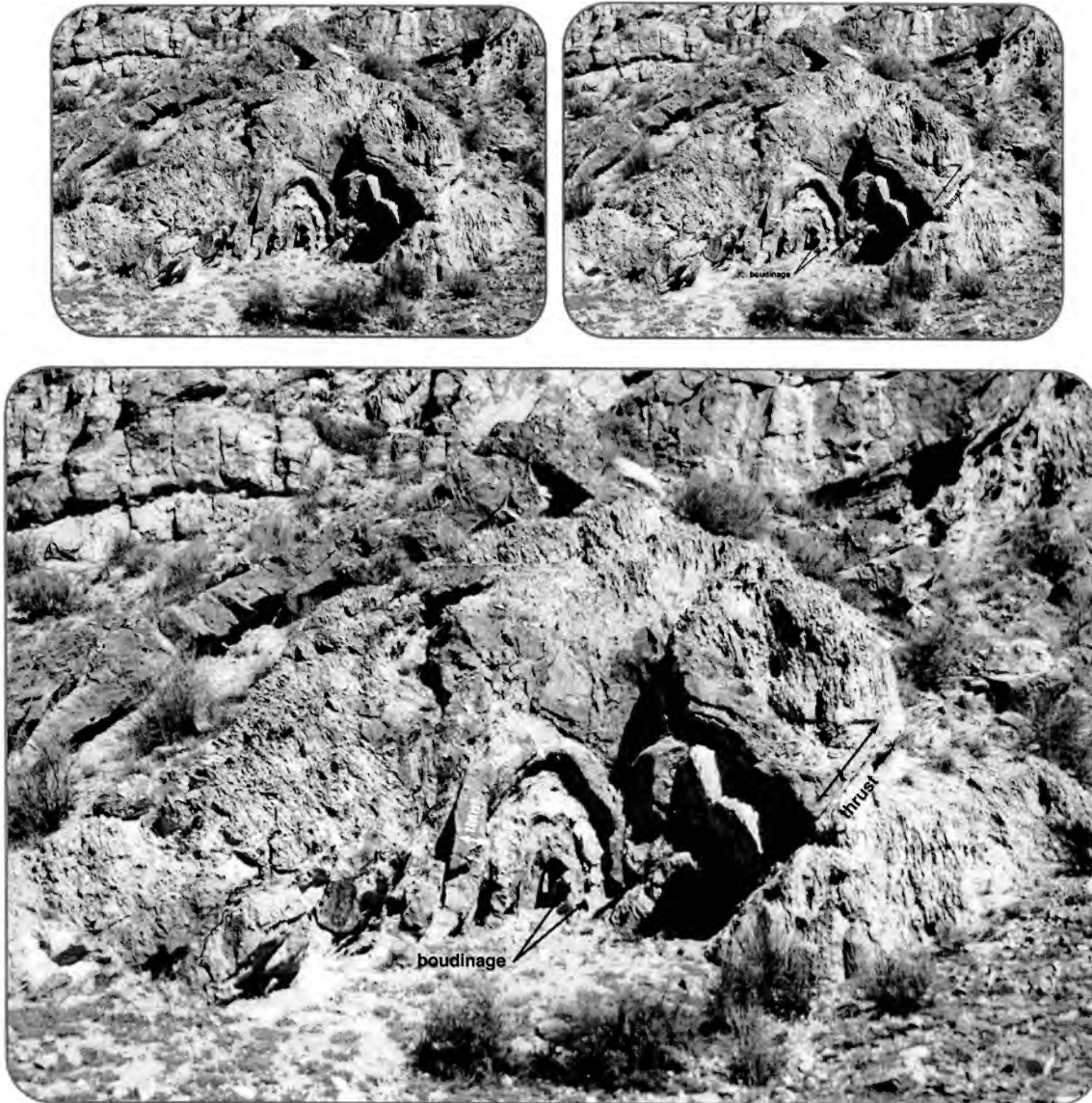
Little Dome, an Asymmetric Doubly-Plunging Anticline

You are looking toward the northwest along the axis of Little Dome in the northwestern Wind River Basin of Wyoming. Little Dome has a rather unique asymmetry. Its northeastern flank dips 40 to 50 degrees. Its southwestern flank immediately adjacent to the crest dips only about 20 degrees, then kinks abruptly to overturned. The exposed formations range from Lower to Upper Cretaceous.



Asymmetric Plunging Nose

You are looking northward at Conant Creek Nose, an anticline without closure, in the south-central Wind River Basin of Wyoming. It plunges northwestward down into the basin under the unconformably overlying Tertiary formations.



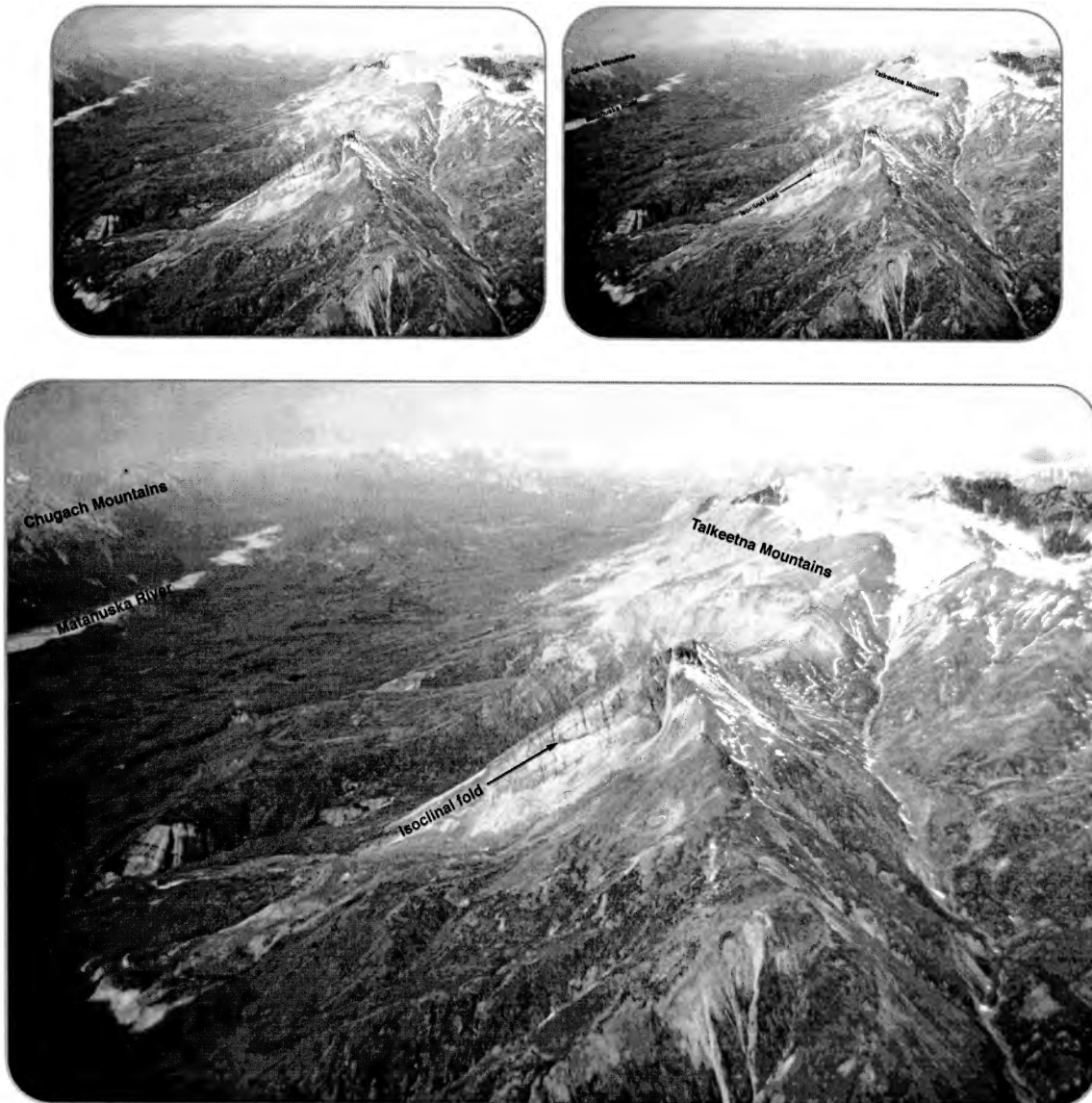
Drag Folds with Boudinage in Flanks

You are looking toward the north at drag folds developed along a small thrust fault north of the Big Hole River east of Glen, Montana. The folds are in the middle limestones of the Cretaceous Kootenai Formation. They are similar folds, meaning that they tend to maintain the shape of the fold throughout its amplitude. To do this the layers of limestone thin along the flanks and thicken into the axial areas. As material has migrated from the flanks into the axial areas, the beds have thinned and stretched into sausage-like structures, boudinage.



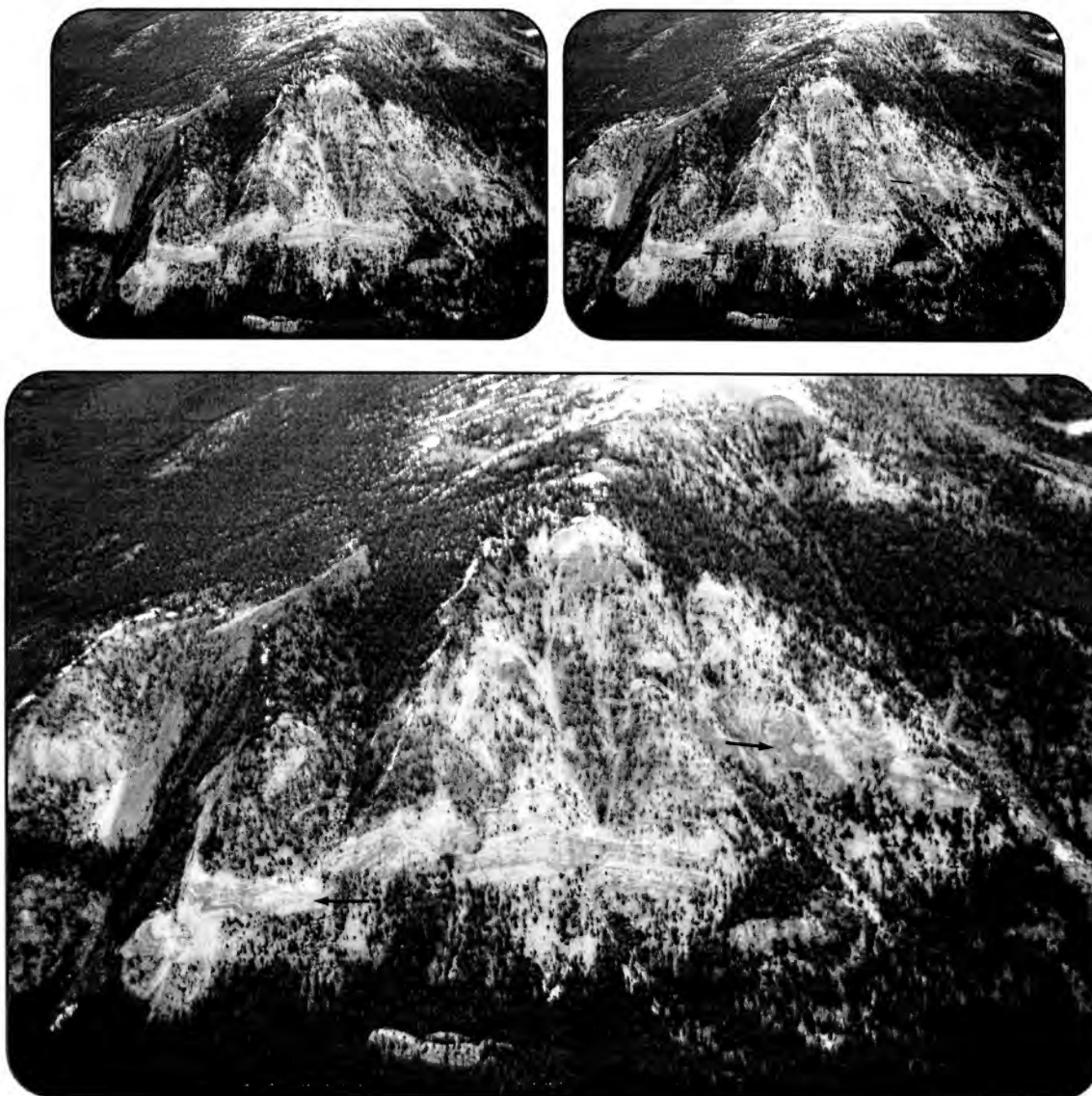
Folds with Both Concentric and Similar Characteristics

You are looking toward the north at a fold in the middle limestones of the Kootenai Formation north of the Big Hole River east of Glen, Montana. The fold's western flank is cut by small thrusts that have steps in them where they cross the competent limestone beds, but notice how the limestone beds stretched and necked down before they broke. The limestone crumpled in the axial area of the fold; whereas, the interbedded shale behaved plastically and flowed to thicken in the axial areas and thin along the flanks. Thus, the fold has characteristics of both concentric and similar folds.



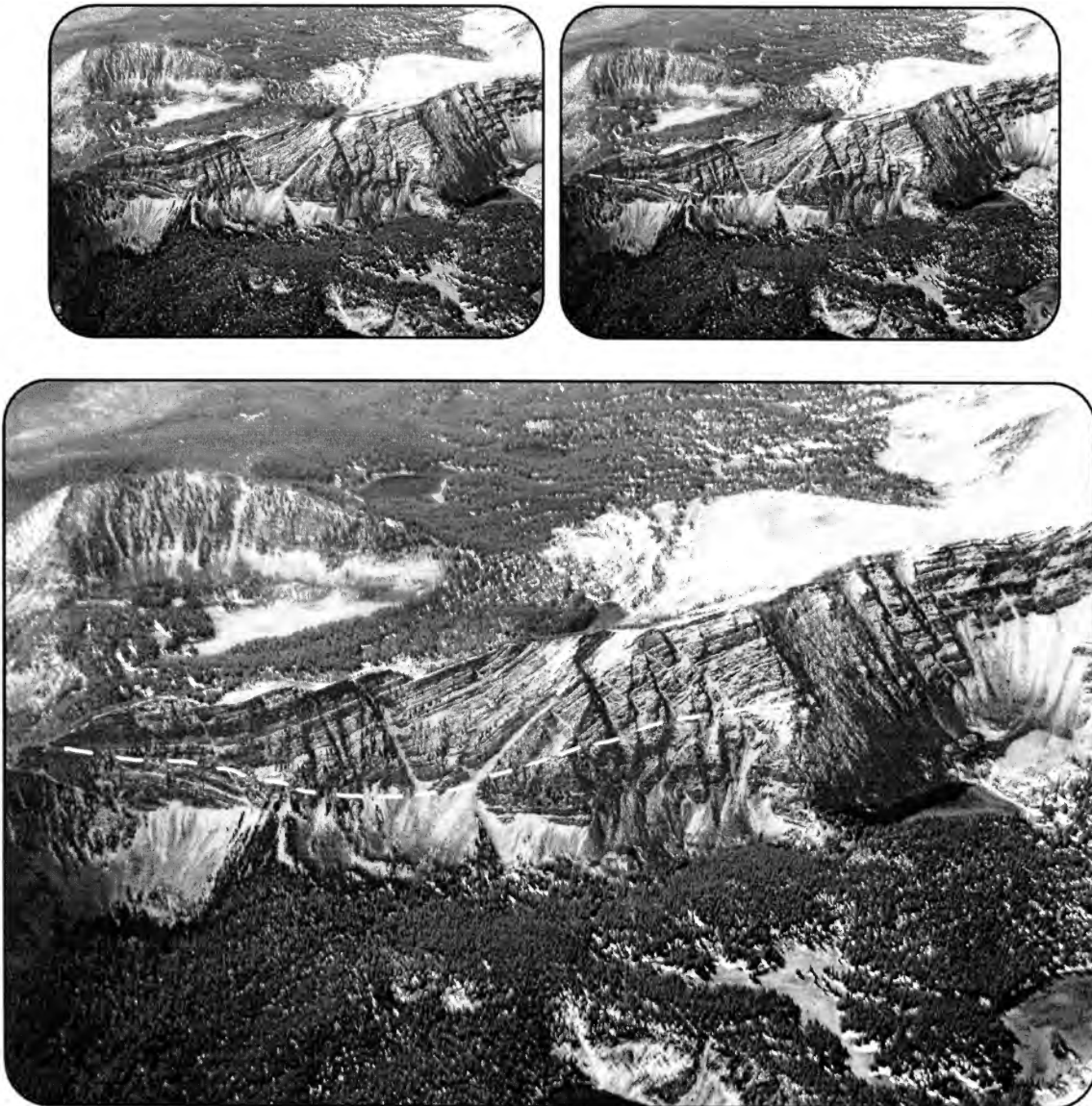
Isoclinal Fold Chickaloon Pass

You are looking toward the west on the western side of Chickaloon Pass in south-central Alaska. The Chugach Mountains are composed of a melange of deep sea volcanics and sediments thrust up (obducted) against the continental rocks of the Talkeetna Mountains. The isoclinal fold may have formed as the Chugach terrane slid up and northward onto the Telkeetna terrane.



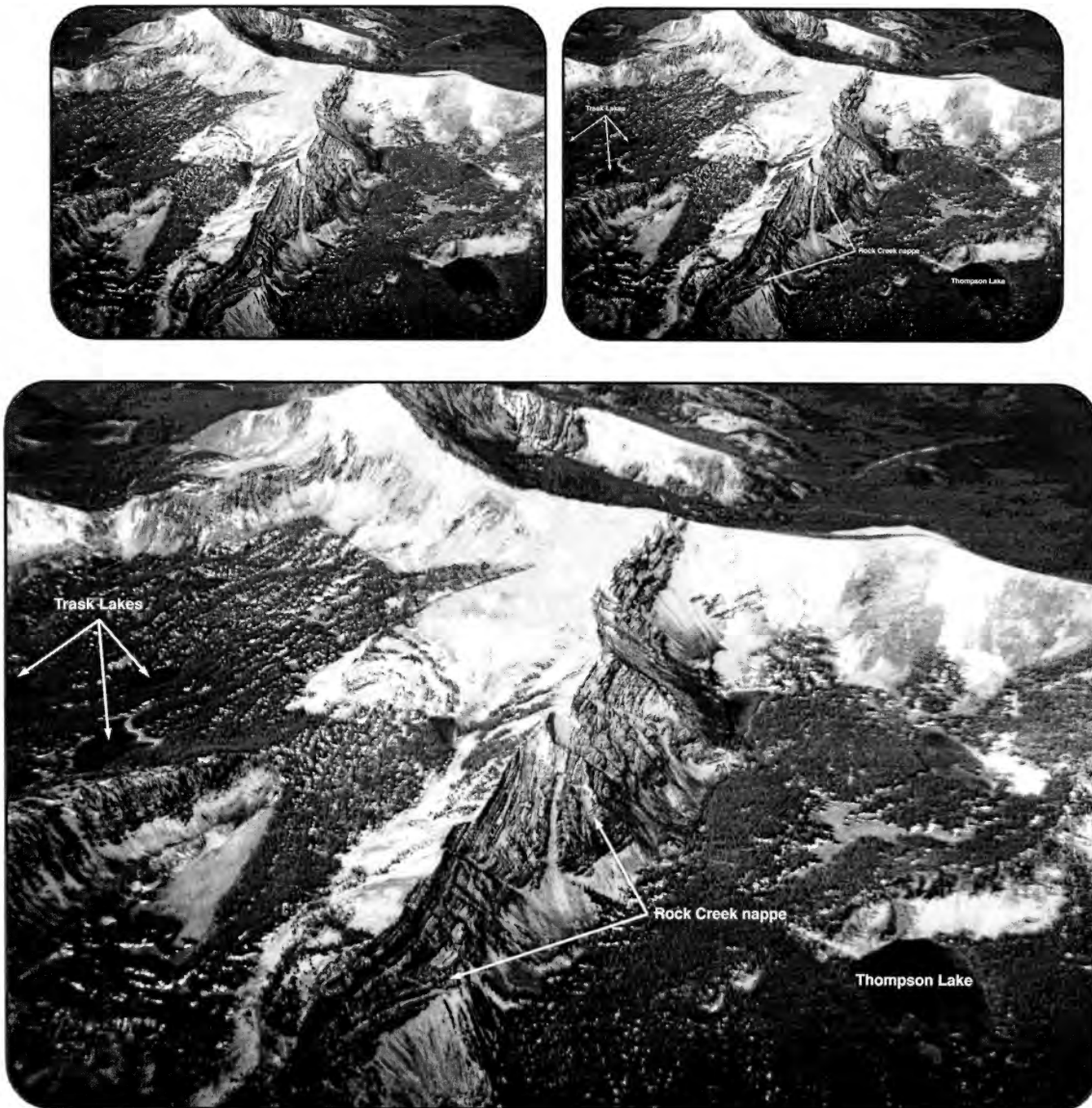
Foster Creek Nappes

You are looking at a mountain on the eastern side of Foster Creek in the Flint Creek Mountains northwest of Anaconda, Montana. The arrows point to nearly recumbent, isoclinal folds in the Madison Limestone.



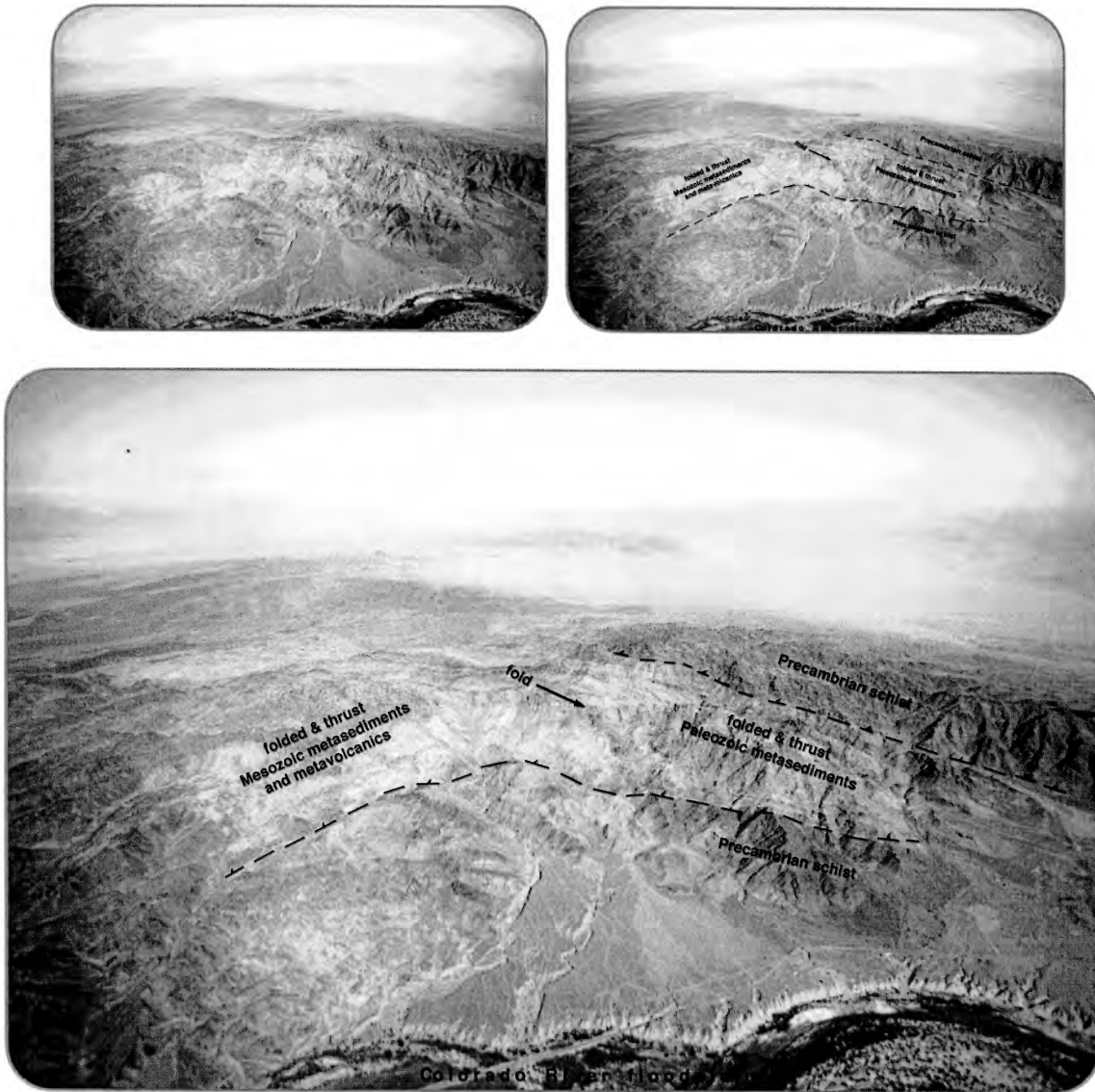
Rock Creek Nappe

You are looking southeastward at the wall of a cirque near the head of Rock Creek in the northern Flint Creek Mountains of southwestern Montana. The dashed line follows the trace of the axial plane of this nearly recumbent fold, a nappe. Because the overturned limb is not thinned, the fold probably migrated downhill like a rug folding over itself, the upper limb rolling over the lower limb as the fold slowly migrated down the slope created as molten rock of the Idaho batholith pushed up the terrain 65 miles to the west.



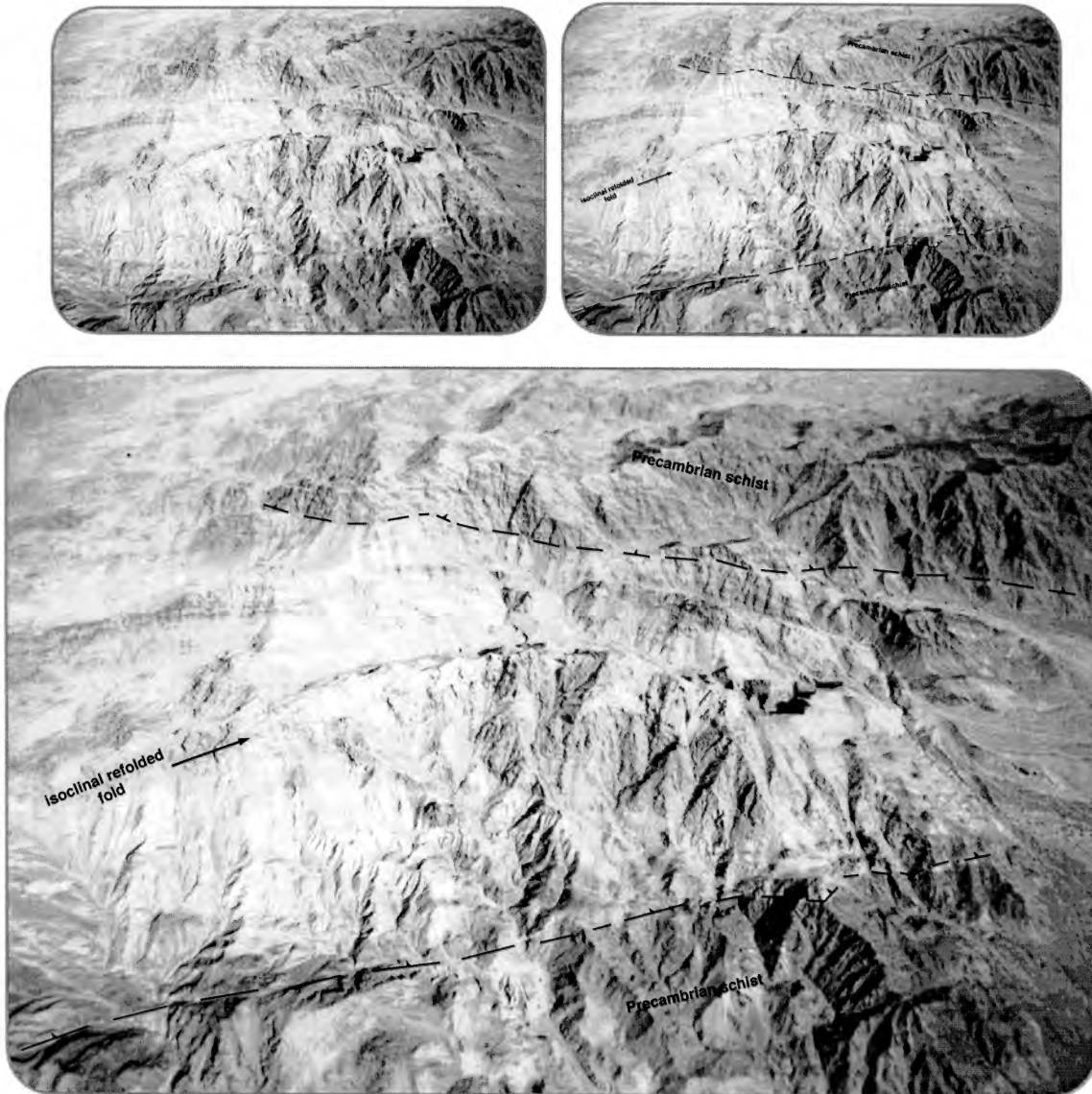
Rock Creek Nappe

You are looking southwestward at the Rock Creek nappe in the northern Flint Creek Mountains of southwestern Montana. Its axial plane dips gently to the southeast under that of the overlying structure between it and Trask Lakes.



Complex Overtuned Syncline

You are looking toward the west across the Colorado River floodplain at the Riverside Mountains in southeastern California. Only two of the numerous thrust traces are followed by dashed lines on the picture. In the Paleozoic sequence the thrusts cut refolded isoclinal folds, one of which is labelled and is shown in closer view on the next page.



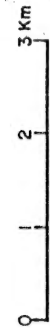
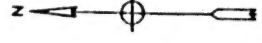
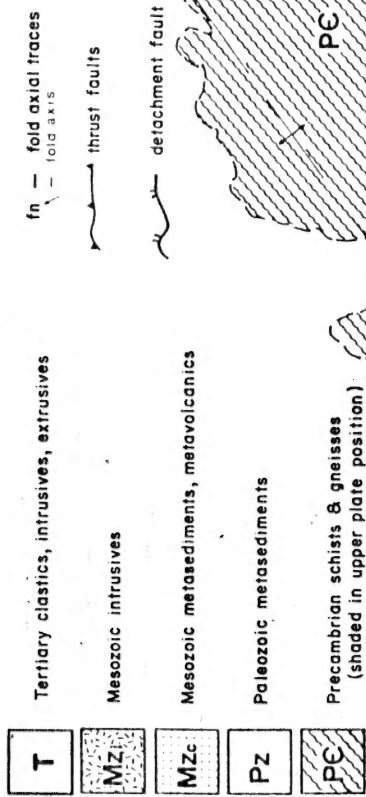
Isoclinal Refolded Fold

You are looking northwestward at the complex of thrusts and isoclinal refolded folds in the Riverside Mountains of southeastern California. This area is outlined on the map* on the next page.

*Lyle, John H., 1982, "Interrelationship of Late Mesozoic Thrust Faulting and Mid-Tertiary Detachment Faulting in the Riverside Mountains, Southeastern California", Anderson-Hamilton Volume, "Mesozoic-Cenozoic Tectonic Evolution of the Colorado River Region, California, Arizona, and Nevada", edited by Eric G. Frost and Donna L. Martin, in conjunction with a Symposium and Field Trip for The Geological Society of America, p475.

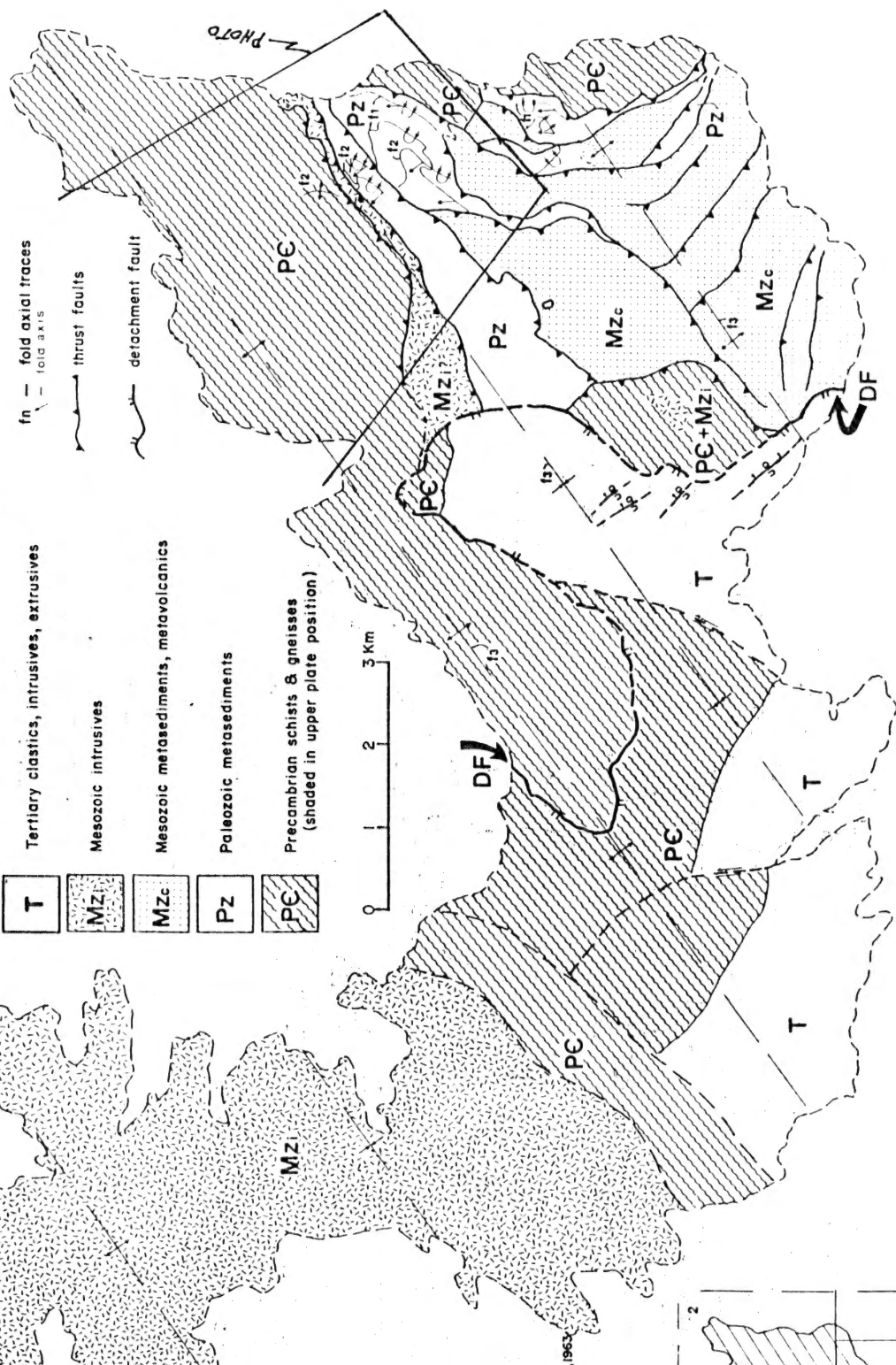
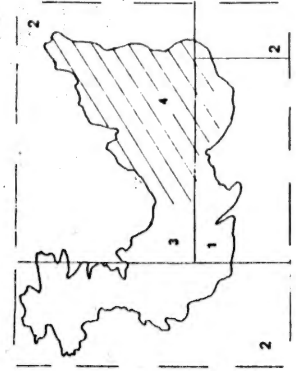
SIMPLIFIED GEOLOGIC MAP OF THE RIVERSIDE MTS.

EXPLANATION

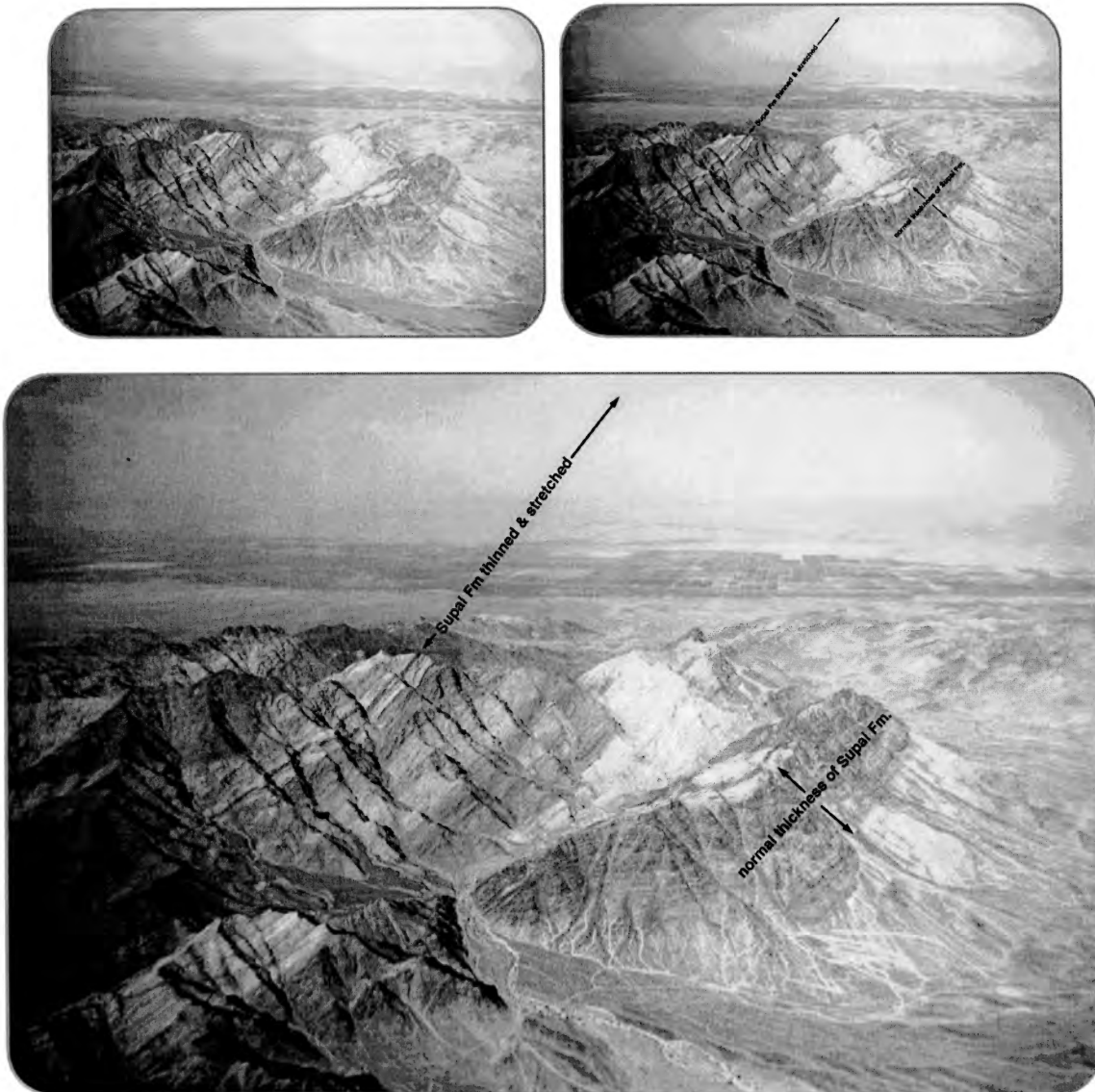


INDEX TO LOCAL GEOLOGIC MAPPING

1. Hamilton, W., 1964
2. Hamilton, W., 1963, unpublished from the Needles, 2° geologic map, 1963
3. Corr, W. and Dickey, D., 1980
4. Lyle, J.H., 1982



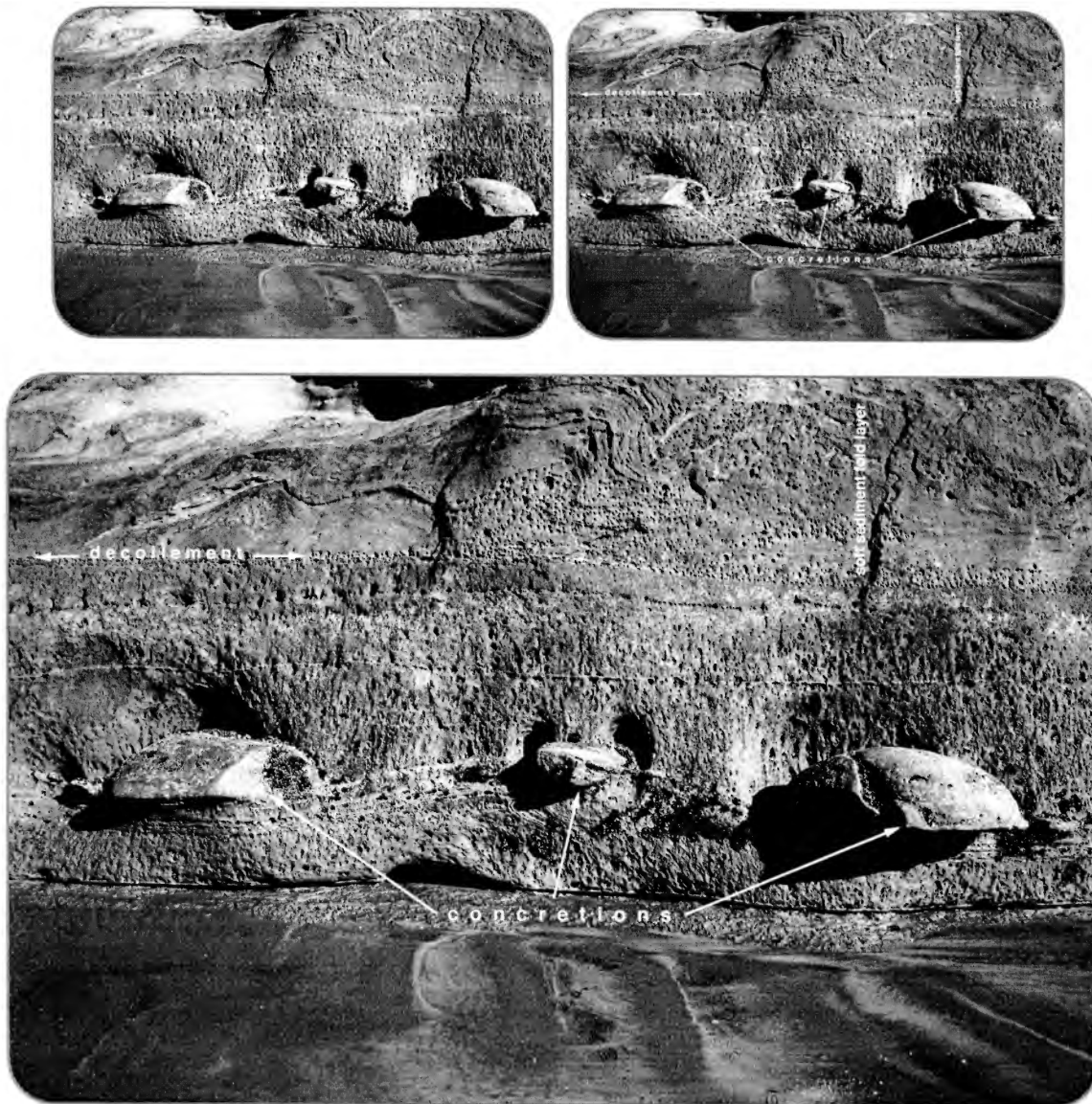
Simplified geologic map of the Riverside Mountains, California. Geology is characterized by two distinct tectonic domains: 1) an upper-plate terrane characterized by brittle Mid-Tertiary extensional deformation in conjunction with development of the detachment fault and f_3 antiforms and synforms, and: 2) a lower plate that reflects f_3 folds yet preserves multiple Mesozoic compressional deformations (f_1, f_2 fold sets) involving interleaves of upright and overturned limbs of Precambrian, Paleozoic and Mesozoic units.



Extreme Thinning of Overturned Flank

You are looking northeastward along a syncline in the Big Maria Mountains of southeastern California. The upright limb, on the right contains beds of normal thickness. The overturned limb on the left has been greatly thinned and stretched by a factor of 100. A section of this Grand Canyon sequence that is normally 5000 feet thick is reduced, in places, to just 50 feet in the overturned limb.*

*Hamilton, Warren, 1982, "Structural Evolution of the Big Maria Mountains, Northeastern Riverside County, Southeastern California", in Anderson-Hamilton Volume - "Mesozoic-Cenozoic Tectonic Evolution of the Colorado River Region, California, Arizona, and Nevada", edited by Eric G. Frost and Donna L. Martin in conjunction with a Symposium and Field Trip for The Geological Society of America.



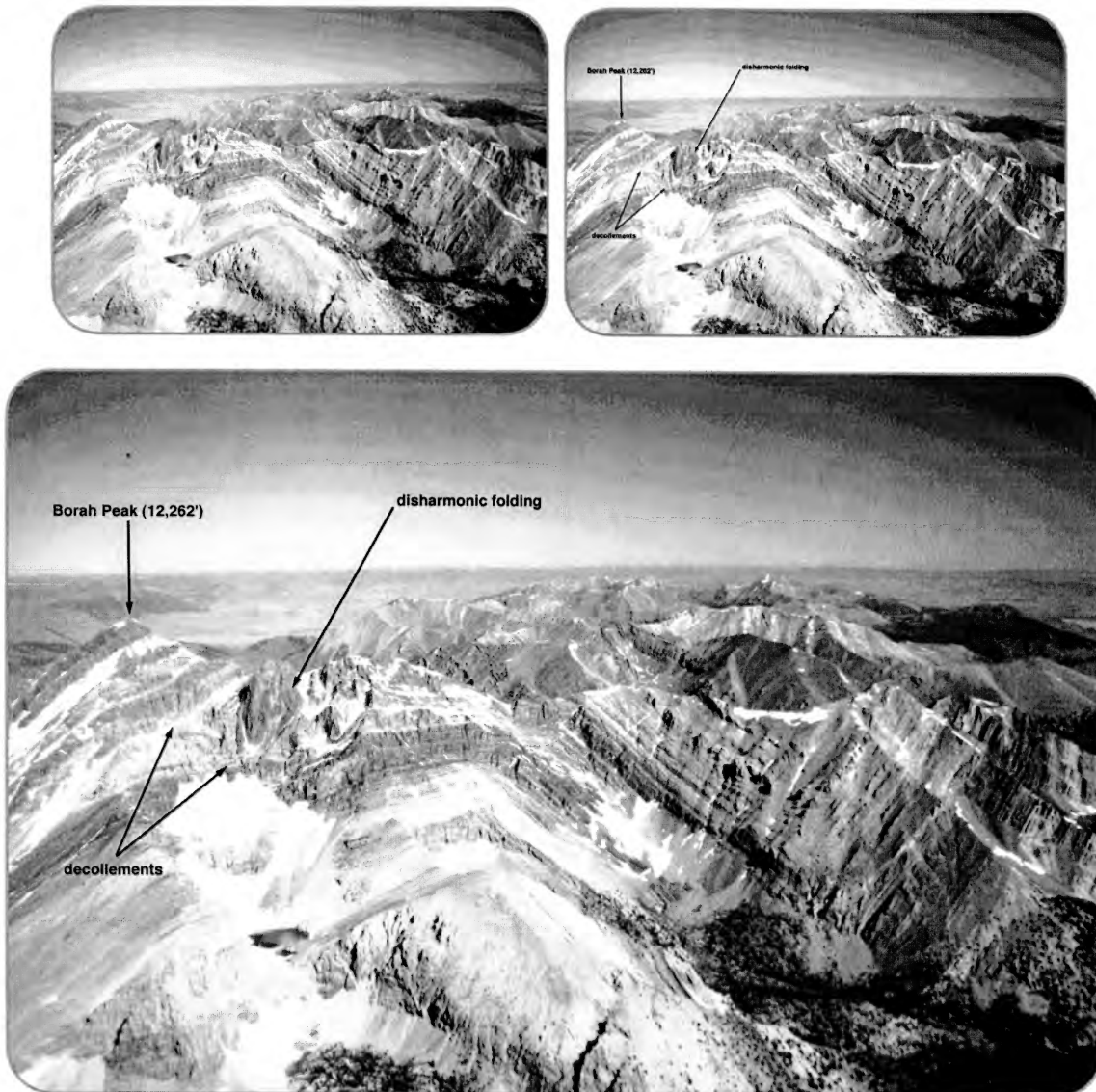
Soft Sediment Folds

You are looking at a sea cliff cut in the Mt. Messenger Sandstone just south of the mouth of Rapanui Stream on the western side of New Zealand's North Island. A layer of water-logged sand folded as it slid on a decollement over more cohesive sediments underlying it. It slid, shortly after it was deposited during the Miocene epoch, down the eastern flank of a basin along the edge of the Tasman Sea. Concretions formed later as water migrating through the sediment deposited calcite concentrically around sea shells or other nuclei. Picture taken June 28, 1997.



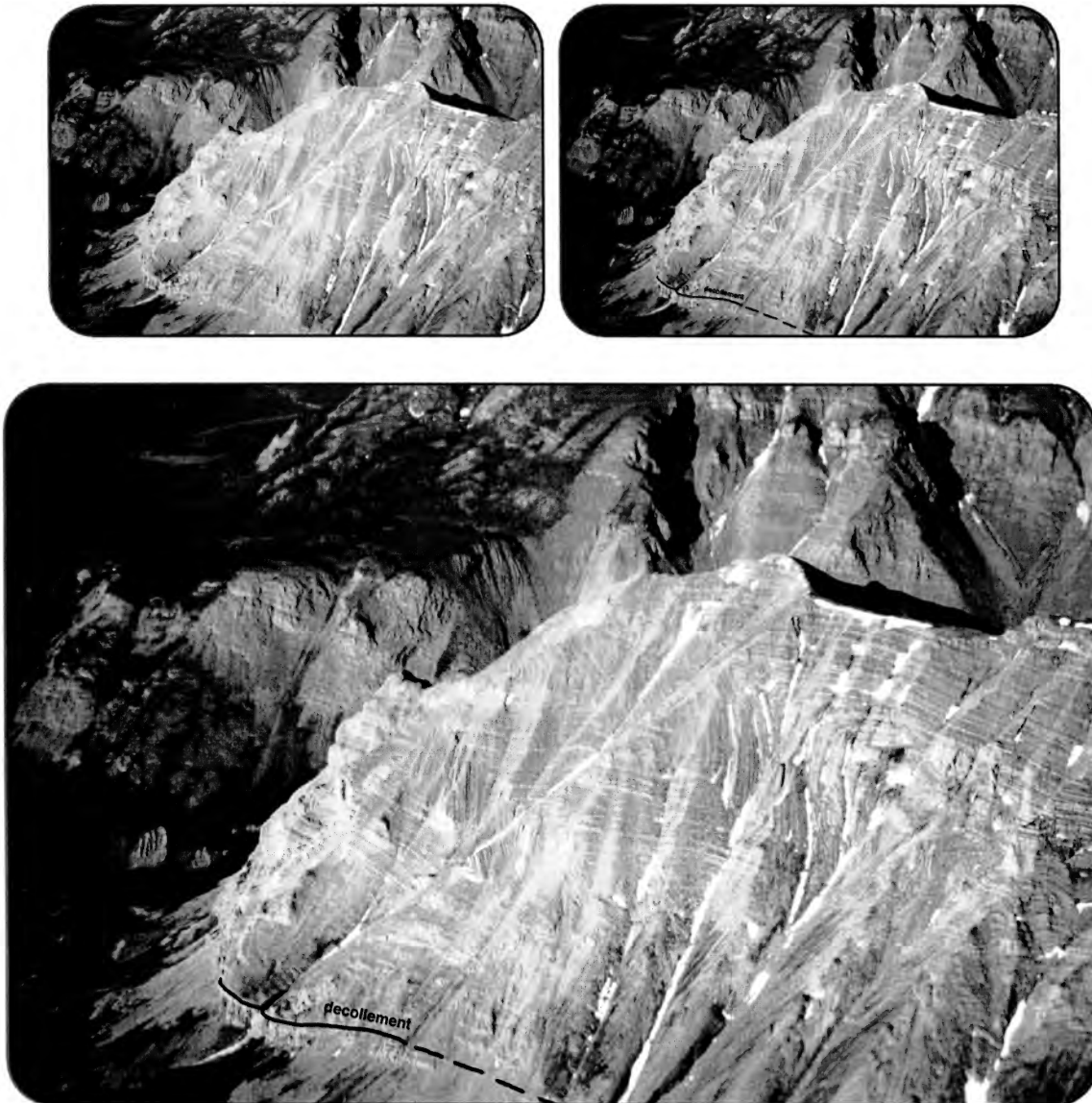
Extreme Soft Sediment Folds

The Mount Messenger Sandstone was deposited on the eastern flank of a basin that developed in western New Zealand and the Tasman Sea in the Miocene. Water-logged sands contorted into folds soon after they were deposited as they slid over a decollement on more stable underlying layers. The sliding could have been triggered by an earthquake. These folds are exposed on a sea cliff north of the mouth of Rapanui Stream on the western side of New Zealand's North Island. Picture taken June 14, 1998.



Crumpled Axial Area

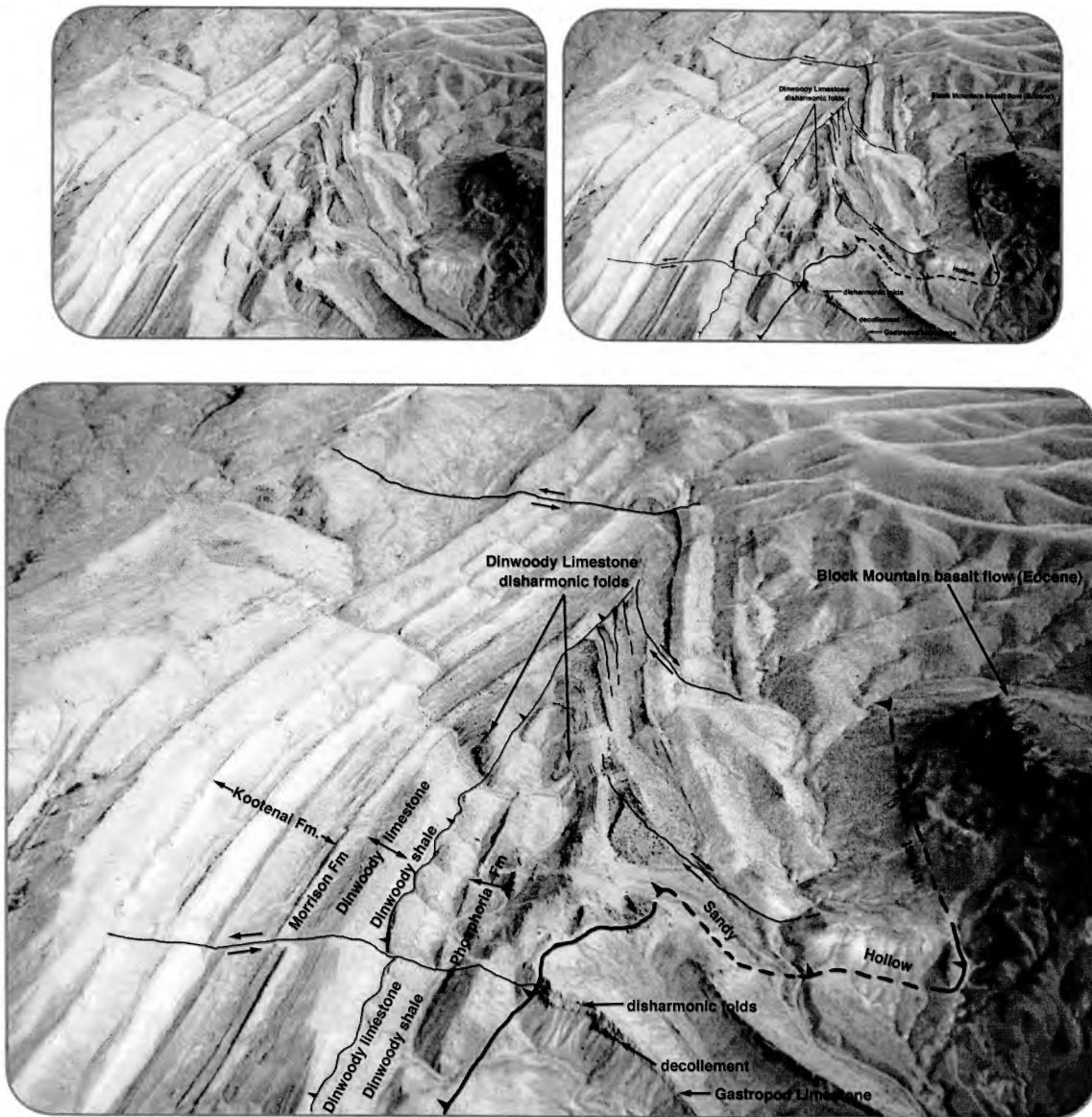
You are looking northwestward at folds in the Lost River Range near Borah Peak, the highest mountain in Idaho. The large scale crumpling of the beds in the axial area of the anticline is an example of disharmonic folding. The crumpled beds had to slide along decollements as they folded independently of the beds above and below.



Disharmonic Folds of the Besa River Formation

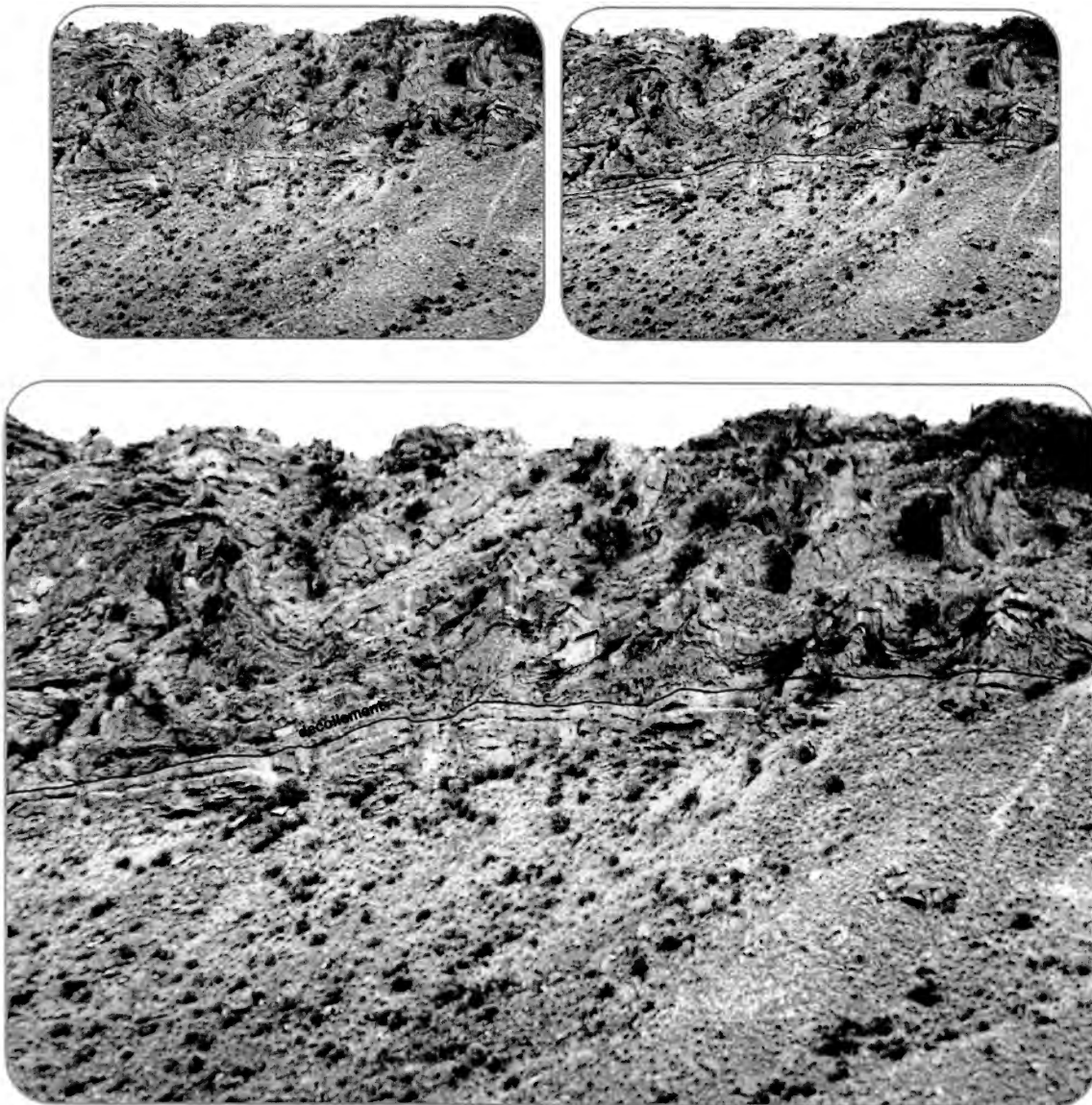
You are looking at disharmonic folds in the Mississippian Besa River Formation outcropping along the Toad River in northern British Columbia, Canada. The thin-bedded Besa River limestones folded into tight folds because of the easy slippage between beds. The decollement appears to be above a basal limestone bed. Because the underlying Devonian shales are only broadly folded, the folding in the Besa River has been attributed to drag below the overriding Mt. Borden thrust sheet.*

* Fitzgerald, E.L. and Braun, L.T., 1965, Disharmonic Folds in Besa River Formation, Canada, AAPG Bull vol 49, no.4, p 418-432.



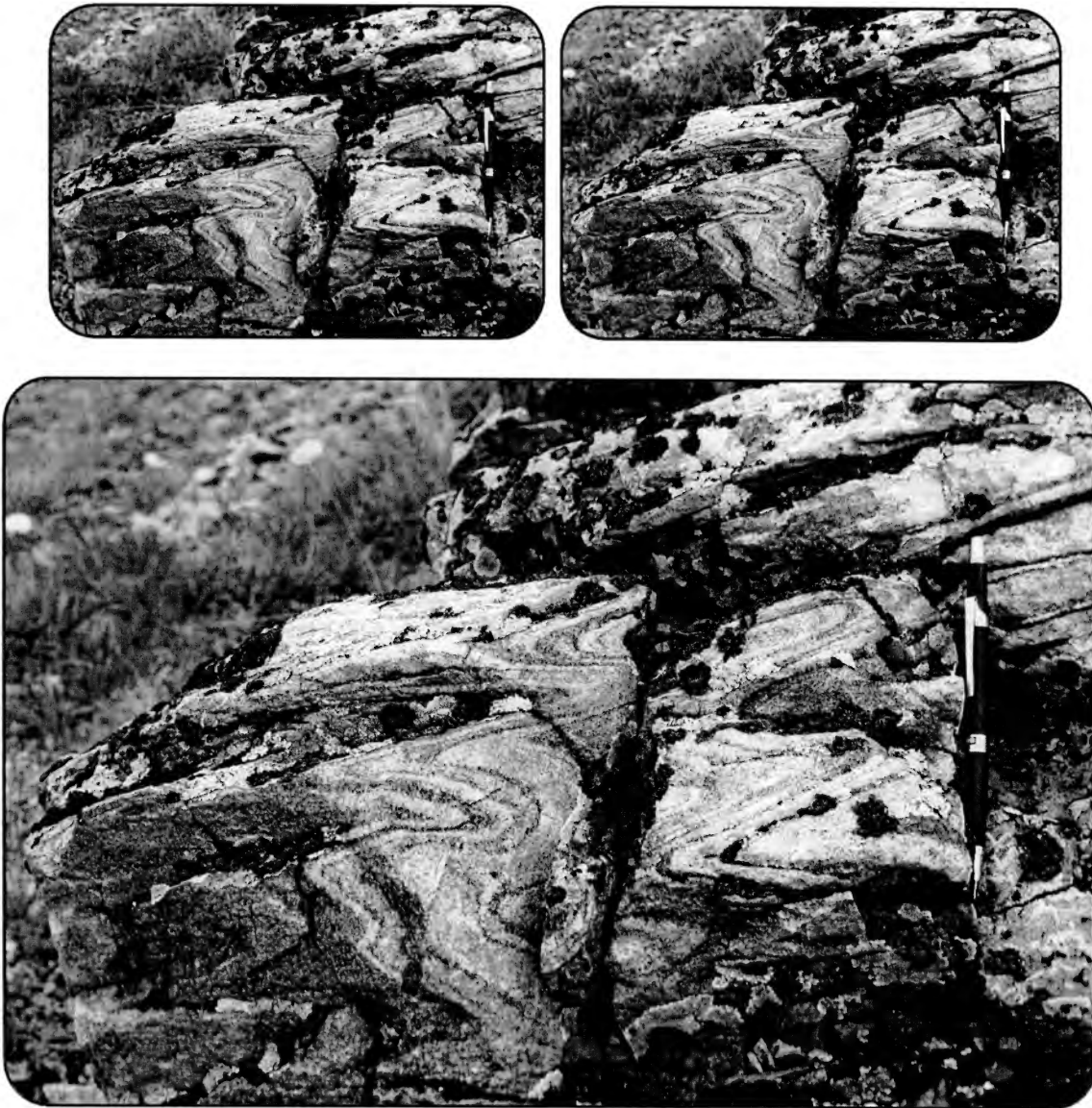
Disharmonic Folds at Sandy Hollow

You are looking northeastward at an area just southeast of McCartney Mountain in southwestern Montana. The upper Dinwoody limestones slid on the lower Dinwoody shale to fold disharmonically between the overlying Morrison and Kootenai Formations and the underlying Phosphoria Formation. The upper part of the Gastropod Limestone was pushed over its basal layers by the Sandy Hollow thrust, forming disharmonic folds that are shown in closer view on the next page.



Decollement at Base of Disharmonic Folds

You are looking eastward at the decollement within the Gastropod Limestone member of the Kootenai Formation on the southeastern flank of Sandy Hollow Anticline. The anticline is located southeast of McCartney Mountain in southwestern Montana.



Similar Folds in Gneiss

This outcrop of Precambrian gneiss is located in the Ironrod Hills near Silver Star, Montana. Its layering is not bedding, but rather a structurally produced compositional banding termed foliation. The foliation has been folded into similar folds that maintain their shape by thinning the folia on the flanks and thickening them in the axial areas. The rock must have been deeply buried, hot, and plastic to fold in this manner at this scale.



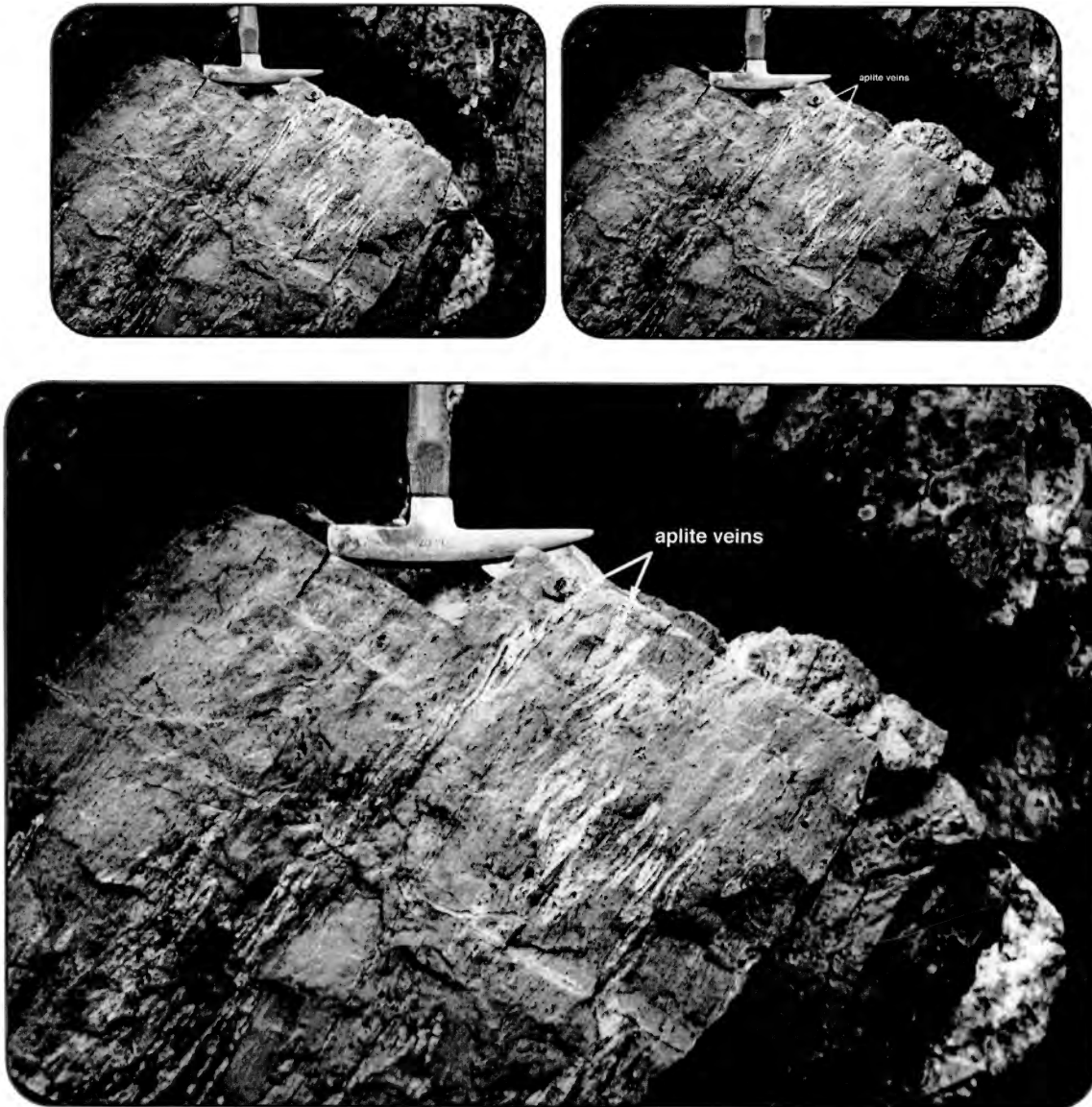
Foliation and Lineation

This outcrop of Precambrian gneiss is located in the Ironrod Hills near Silver Star, Montana. Its layering is not bedding, but rather a structurally produced compositional banding termed foliation. The foliation has been folded into similar folds that maintain their shape by thinning the folia on the flanks and thickening them in the axial areas. The rock must have been deeply buried, hot, and plastic to fold in this manner at this scale. This outcrop also shows lineation, produced by the alignment of hornblende crystals. The lineation here is parallel to the fold axes.



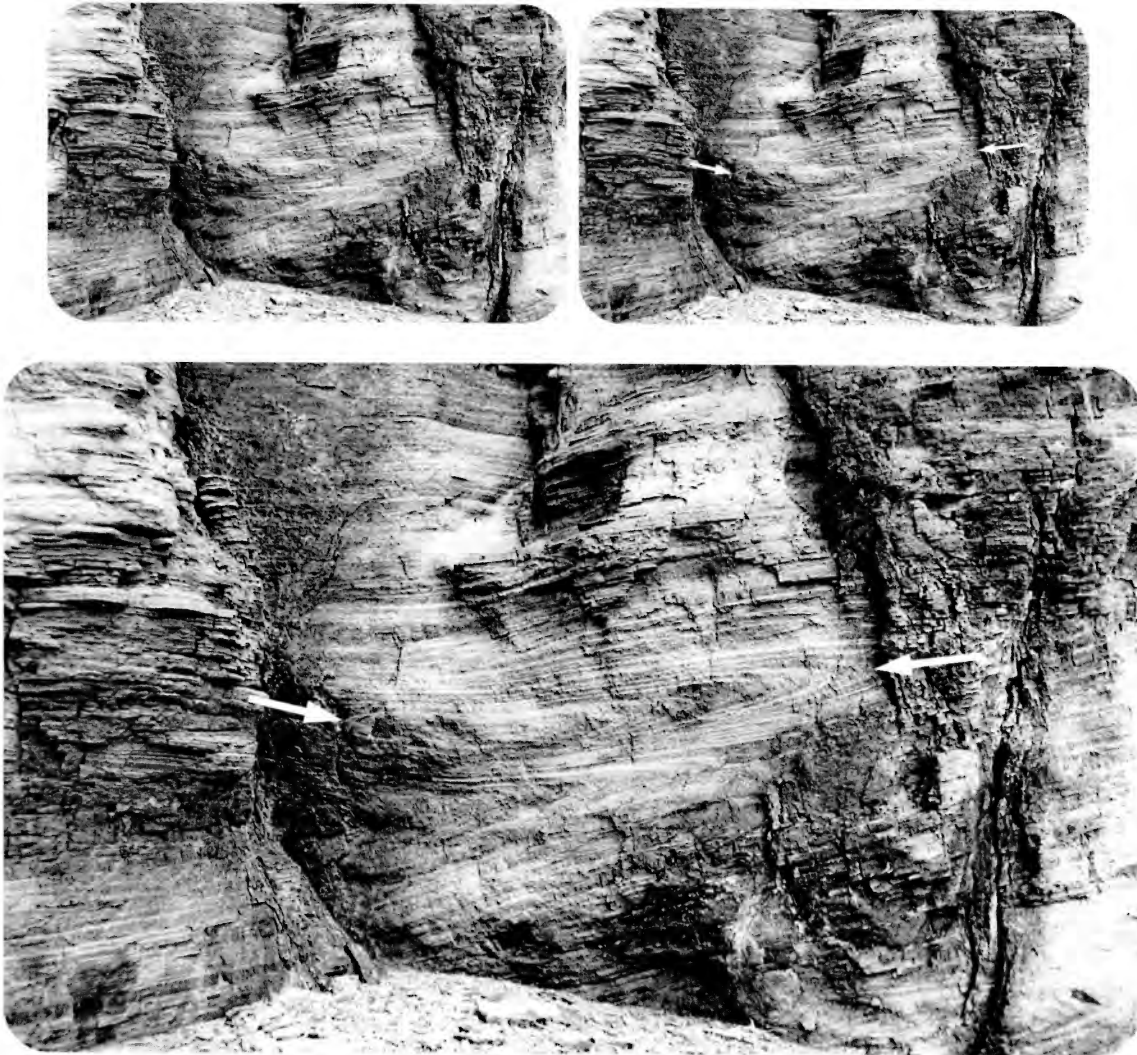
Refolded Fold

This refolded fold occurs in gneiss of the Manhattan Schist near White Plains, New York. The first folds are isoclinal. They were refolded along axes that are nearly parallel to those of the first-formed folds.



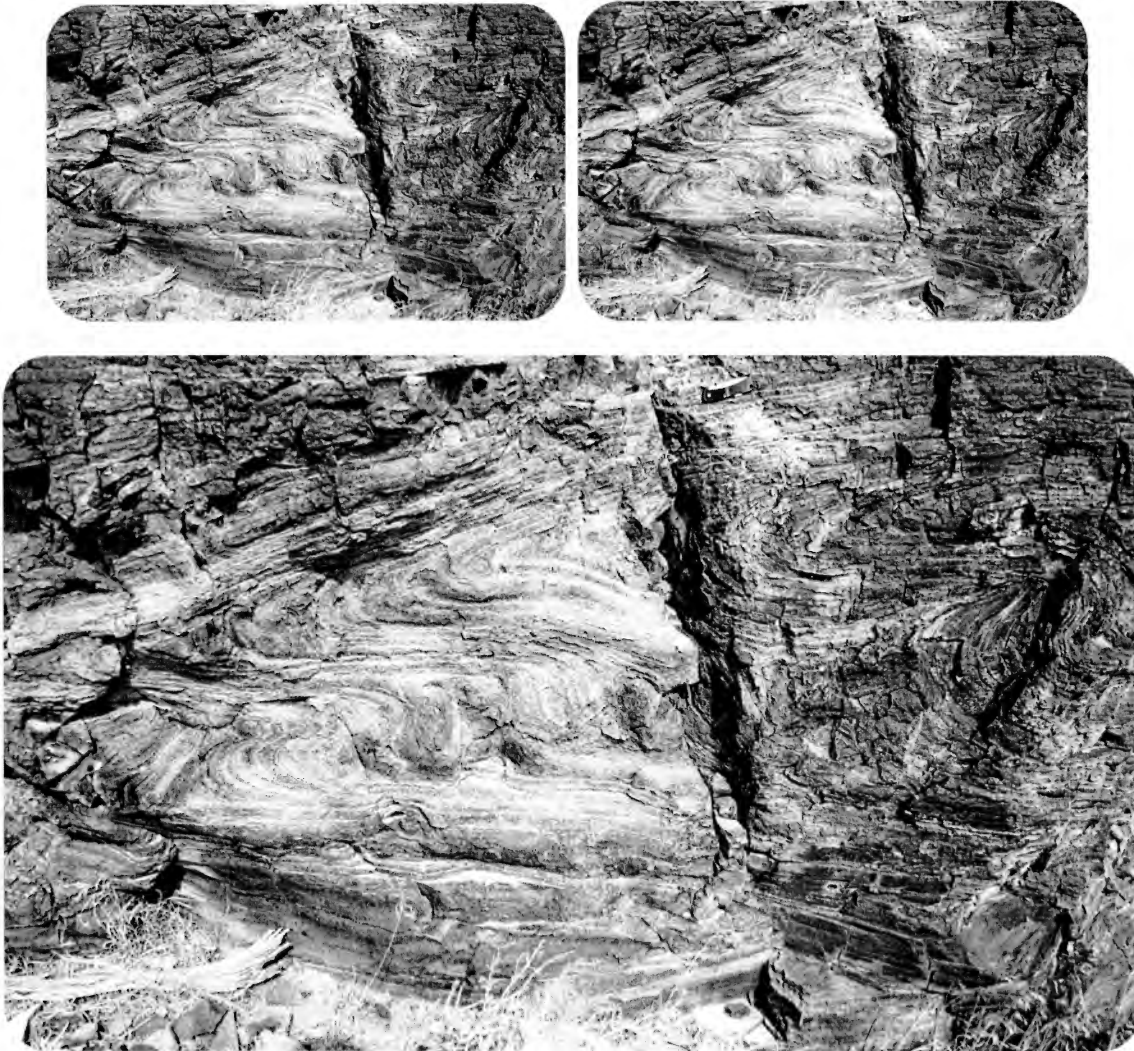
Ptygmatic Folds

The Precambrian Greyson shale has been contact metamorphosed to a greenish gneiss on a roof pendant that hangs down between the Butte Quartz Monzonite and the Rader Creek Granodiorite northeast of Toll Mountain in southwestern Montana. If the veins of Aplite were intruded as planar veins following fractures across the beds, then their folding reflects the thinning and stretching of the gneiss. Alternatively, the veins of aplite may have been intruded in the form of the folds while the gneiss was being metamorphosed. These folds in aplite usually occur adjacent to batholiths. They are called pygmatic folds.



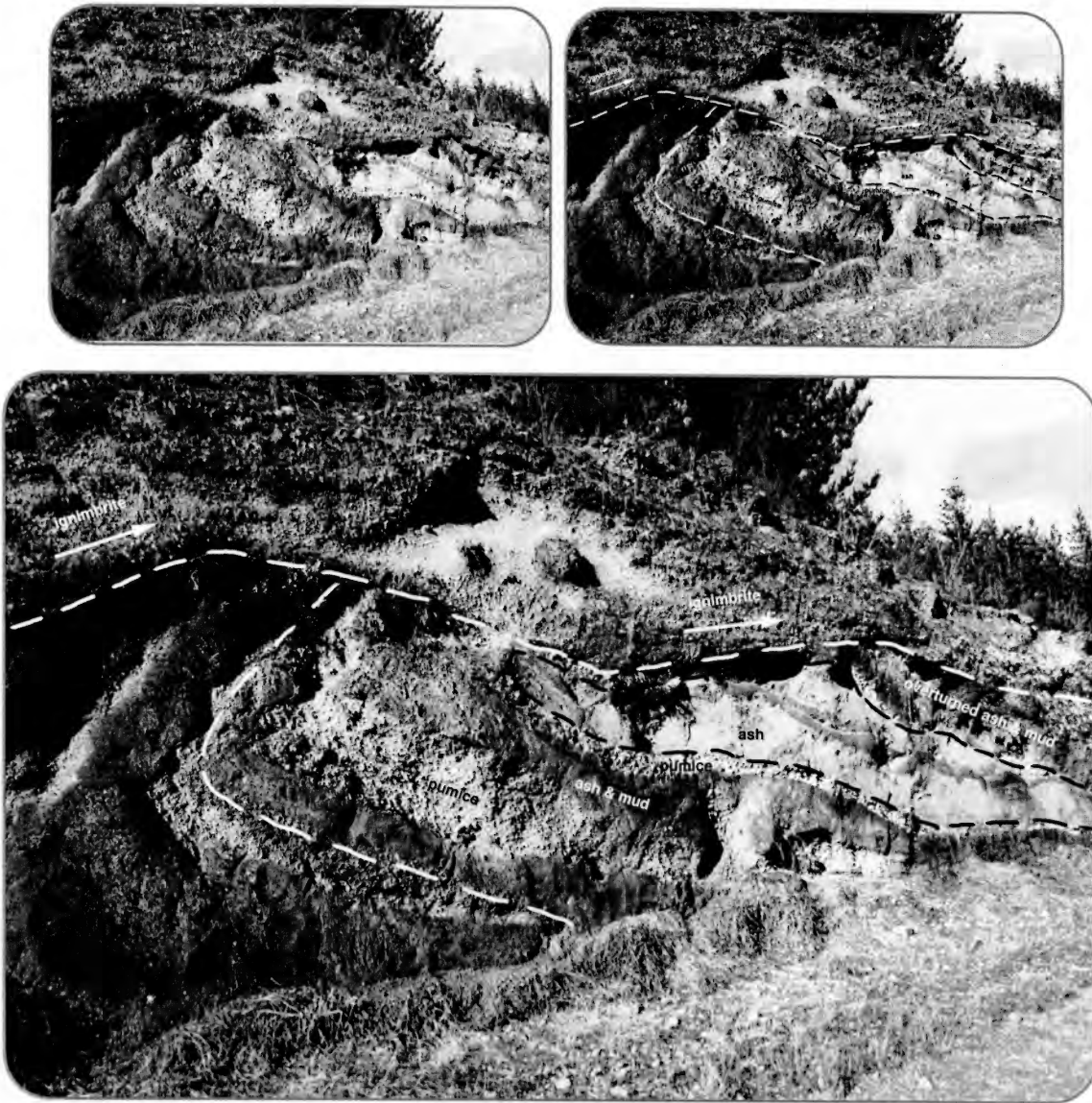
Tongue-like Folds in Welded Tuff

You are looking at cross sections of tongue-like, nearly isoclinal and recumbent folds in the Tuff of McMullan Creek at Grey's Boat Landing on Salmon Falls Creek Reservoir in southwestern Idaho. The arrows point to the closed ellipse cross section along the edges of the tongue-like fold. These folds presumably formed as the high-velocity flows of ground-hugging hot ash agglutinated into lava-like flows while they were being emplaced. On the next page the folds are shown on an exposure that is nearly perpendicular to this one.



Tongue-like Folds in Welded Tuff

You are looking toward the northwest at an exposure nearly parallel to the length of tongue-like, isoclinal, recumbent folds in the Tuff of McMullan Creek at Grey's Boat Landing on Salmon Falls Creek Reservoir in southwestern Idaho. The folds cascaded over one another in response to flow directed toward the southwest, presumably as the hot ash flow agglutinated to form a lava-like flow.



Isoclinal Fold in Volcanic Tuffs

Arrows show the approximate direction of flow of the climax eruption of the Taupo ignimbrite over air falls of ash, mud, and pumice that plastered the landscape during the earlier phases of the eruption. The Taupo ignimbrite was deposited 1800 years ago from a dense ground-hugging cloud of hot ash and pumice traveling at an estimated velocity of 600 to 900 km/hour (~375 to 560 mph)*. It tore up the earlier layers, rolled them over in an isoclinal fold, and scoured them as shown. The black dashed line outlines the core of the isoclinal fold in the earlier eruptive deposits. Picture taken near Lake Taupo, New Zealand, on May 27, 1998.

*Wilson, C.J.N., and Houghton, B.F., 1993, "The Taupo Eruption", Institute of Geological & Nuclear Sciences Information Series No. 12.