Certain Indicia of Dip in Rocks.

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The object of this paper is to bring together certain indications of dip and the direction of dip in rocks which the writer has observed in his field work. All of these indicia have been noted doubtless by other observers of geological conditions. However, they are brought together here in the hope that the collection may be of assistance to students of structural problems in geology.

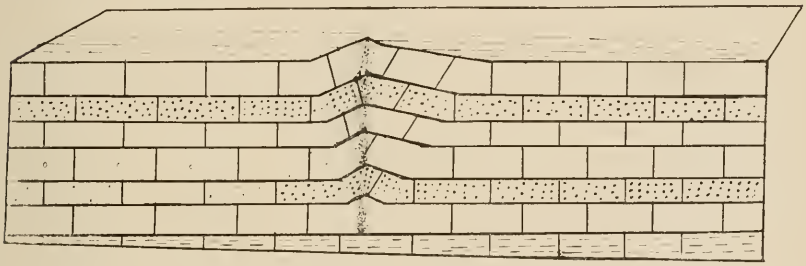

Fig. 1. Cross-section of strata, showing dipping beds with a gulch approximately at right angles to the dip. Right surface of rocks in gulch damp, left surface, dry.

Wet or Damp Surfaces.—In the case of an outcrop extending approximately at right angles to the dip of the beds the exposed surface of the rocks on the lower side of the dipping beds may be bathed in moisture. The presence of the moisture is due to the seepage of water from the porous layers in the rocks. Such seepage can take place only under certain conditions of humidity and would not be noticeable in an arid region. If the outcrop is in a railroad cut or in a stream with precipitous banks the outcrop on the opposite side from the damp surface will be dry because the water is conducted away from its surface, instead of toward it. The conditions are illustrated in the following diagram in which the shaded side of the cut on the down-dip side is kept moist by water flowing along the bedding planes and through porous layers, while the surface of the rocks on the opposite side of the cut is dry because the water is conducted away from the exposure. If

the dip were, say, a southwest dip, then the southward direction of the dip would be revealed by wet surfaces on the north side of outcrops, while the westward dip would be revealed by moisture on the east side of exposures.

Springs.—Such conditions as have been outlined above often result in the formation of springs. Sometimes a chain of springs is formed

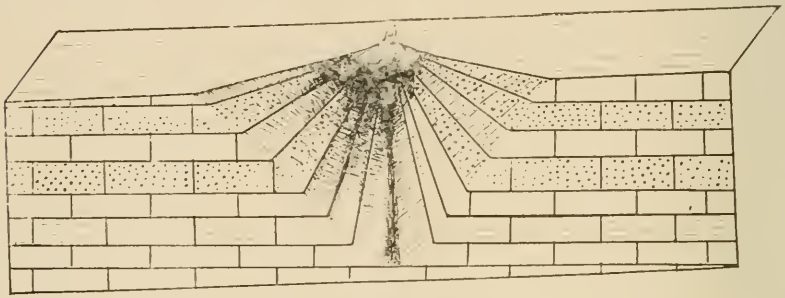

Fig. 2. The case of a stream cutting through strata approximately at right angles to the dipping beds. Springs will be formed at the contact of porous and impervious layers on the left bank of the stream.

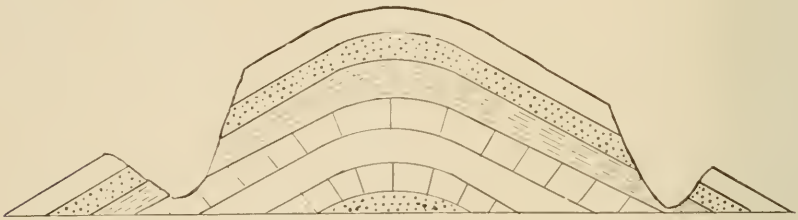

Fig. 3. Showing cross-section of a partly disected anticline. Springs may be formed in the valleys on each side of the axis at the points of contact of pervious and impervious layers.

along an exposure on its down-dip side. The essential conditions for a spring, such as a porous layer overlying an impervious one, must be present. Springs are of especial value as indicia in cases of concealed outcrop. Even if the bed-rock be concealed by mantle rock, springs often break forth at the point of contact of the pervious and impervious beds and by observing the position of these along the valley walls of cross-cutting streams, as in the case of wet surfaces, the direction of dip may be determined.

Springs are also good indicia of reversal of dip. Take for example the occurrence of a porous bed overlying an impervious bed in an anticline. Springs will be formed one each side of the anticline at the point of contact of the porous bed with the impervious one. If the anticline is a symmetrical one a chain of springs may occur at about the same elevation on each side of the fold. If the anticline is unsymmetrical the springs may occur at a higher elevation on one side than on the other.

Springs may also indicate the reversal of dip produced by the downthrow of a block along a normal fault. The springs will occur on the banks of depressions following the general direction of the strike and on the down-dip side of the outcrop.

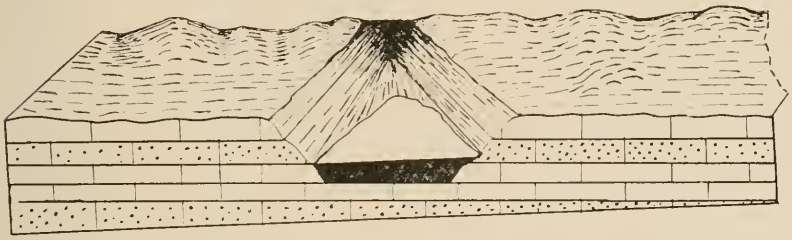

Fig. 4. Shows pool of water formed on surface of dipping bed. Note position of water level with reference to position of bedding planes on each side of pool.

Surface of Pools.—The surface of pools of water in inclined strata furnishes a horizontal plane by means of which even slight degrees of dip may be recognized. The conditions most favorable to such observations are the presence of inclined beds of hard rock or alternate layers of hard and soft rock which have been crossed by a stream in the bed of which pools have been formed. Using the surface of the water in the pool as a level, even slight dips may be detected by the difference in the elevation of the surface of the water upon layers on opposite sides of the pool. If the water stands on the uneroded surface of a hard layer it will have greater depth on the down-dip side of the pool.

Stream Channels.—The channels of dry streams are useful in determining the direction of dip. In the case of a stream trending in a line which is, in general, parallel with the strike and cutting across hard layers or beds composed of alternate hard and soft layers the

stream will be thrown toward the down-dip side. The channel of the stream will have a more gentle slope on the up-dip side and a more abrupt slope toward the down-dip side. The stream, tending to follow the surface of the hard layer in the bottom of the channel, cuts against the bank on the lower side of the inclined bed making that bank more abrupt by under cutting. At the same time the more shallow depositional area of the stream is on the opposite side and its slope is rendered more gentle.

Overhanging Ledges.—Outcrops of rock in inclined strata which contain layers of sufficient induration to project unsupported form on the upper side of the inclined beds overhanging ledges. These ledges occur in layers of hard rock but are more pronounced in outcrops containing alternate layers of hard and soft rock. Slight degrees of dip

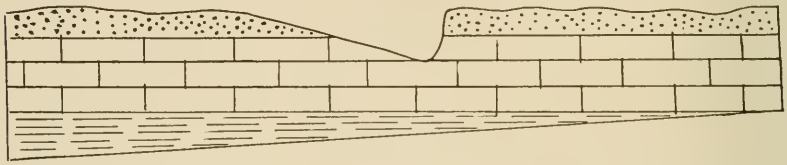

Fig. 5. Notch cut by stream in dipping strata. Note gentle slope on left and abrupt slope on right.

may be noted by observing the plane of shadows under these overhanging rocks. Frequently the direction of dip may be determined by the movement of water on the underside of these ledges.

Caves.—In limestone regions the position of caves serves as an indication of the direction of dip. Wherever a stream cuts through a thick bed of inclined limestone the valley wall opposite the down-dip side of the stream will have a series of caves which mark the positions of tributaries or of former tributaries of the stream. The opposite side of the valley will contain no caves in its wall. If these caves occur on the west side of a valley trending north and south the direction of the dip of the beds is eastward.

In the case of a stream heading in an inclined bed of limestone it frequently happens that more than one cave is formed. Frequently one at each terminal of the small tributaries. If these tributaries be close together and approximately parallel one will necessarily be farther

down on the inclined slope of the beds than the other. Now since these tributaries are supplied with water draining down the surface of the impervious layer beneath the limestone the tributary farthest down on the slope will receive the greater amount of water. Thus it often happens that there is a lower cave from which a stream of water is issuing and an upper cave that contains little or no running water. In regions of such occurrences the cave on the lower part of the slope is referred to as the "wet cave" and the upper one as the "dry cave." The direction of dip is readily determined by the relative positions of these caves.

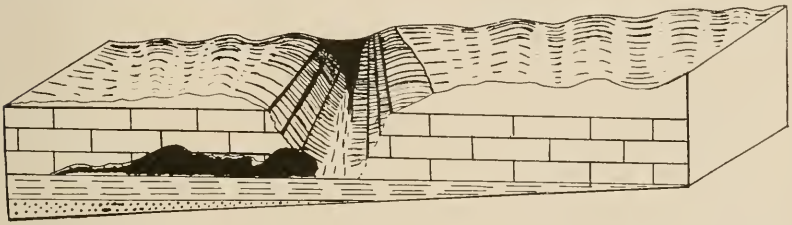

Fig. 6. Shows valley trending at right angles to the dip of inclined strata. Cave and overhanging ledges on left.

Sink Holes.—On moderately to steeply inclined limestone surfaces the shape of the sink holes may be an indication of the direction of dip. As a rule the longer axis of the sink hole will lie parallel to the direction of dip. Erosion produced by water flowing into the sink will be greater on the side opposite the direction of dip. The slope on this side of the sink becomes longer and more gentle. Very frequently there will be one or more short surface streams entering the sink from the side of this gentler slope.

Length of Tributaries.—In the case of a stream cutting in a direction approximately at right angles to the direction of dip the tributaries which follow down the dip will be longer than those which flow up the dip. This would not be true in a rock of uniform hardness devoid of stratification. Such indications are more noticeable in beds containing hard and soft layers of rock.

Indurated Surfaces.—The surfaces of some porous beds of rock which are exposed on the sides of cuts opposite the direction of dip become indurated by the more or less constant evaporation of water

containing minerals in solution. These minerals left behind fill the pores of the rock and unite the individual grains of the rock, thus hardening the surface. The rocks on the opposite side of the cut may lack this degree of induration because, since the dip is away from the outcrop, the greater part of the water is drained away from the surface and the amount evaporated at this point is small.

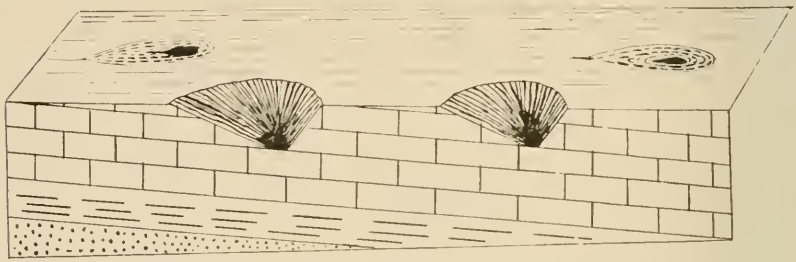

Fig. 7. Cross-section and horizontal section of strata containing sink holes. Note longer axis of holes parallel to the direction of dip.

Deposition of Sediment.—On the surfaces of layers of hard rock which are inclined either in quarries or stream beds the deposition of sediment may indicate the direction of dip. The thicker accumulation of sediment will occur in the direction of the dip. In the case of quarry floors which are formed on the stratification planes the distribution of rock dust and other forms of debris by running water will reveal the direction of the dip.

Distribution of Vegetation.—In inclined beds which outcrop, vegetation is sometimes more abundant on the side of the outcrop opposite the direction of dip. This greater abundance when it does occur is due to the increased amount of moisture and its almost constant supply to the surface of the outcrop through the porous layers which are draining down the dip.