Movement of Limestone Blocks by Floodwaters in Southern Putnam County, Indiana

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An unusual change in the attitude of limestone blocks on a creek floor, following a local flood, is here reported. The area is 5 miles north of Cloverdale, Indiana in the NE¼ SW¼ sec. 12, T. 13 N., R. 4 W. in south central Putnam County. Here Upper Limestone Creek, a branch of Deer Creek, flows over a rolling bedrock surface of middle St. Louis limestone. The limestone beds are from 2 to 12 inches thick, some of which are separated by thin shaly partings. Bedding plane cherts are scattered sparingly over exposed surfaces of the sparsely fossiliferous limestone. The stream bed, which is near the margin of the Wisconsin drift, is eroded through drift to the limestone.

In the local area considered, the stream channel averages 35 ft. wide, and bottoms on limestone. During floods the water spills over the banks upon small flood plain aprons. Upper Limestone Creek descends by a series of small pools and cataracts over a warpy limestone surface with an average gradient of 40 ft./mile. The stream drops over rock ledges from 1 to 3 ft. high at a few points along the course, and these ledges are usually broken along joint lines. In general the stream follows the limestone surface down the regional dip (30-40 ft./mile, southwest). Total relief of the surrounding land averages 100 ft. At least 8 small sink holes are within 500 yds. of the stream on either side of the valley. A few springs are along the valley sides.

This area was being studied during April, 1961 (2). On May 6-7, 1961, 6 inches of rain fell over this section in a 24 hour period. Flood waters rose at least 5 feet at the road bridge. A return visit to the area a few days after the flood revealed these facts. Where the creek formerly flowed over the top of the limestone it now enters a rectangular opening, disappears under the upper limestone beds for 50 ft. horizontally and reappears where the rock has been fractured and torn out. Whereas the limestone in the creek bed was formerly gently warped, now a prominent buckle lies across the creek bed (Fig. 1). The buckle is 35 ft. long, 15 ft. wide, and has been raised 1.2 ft. along the axis. New fractures have opened along one side and along the crest of this upwarp. On the other side of the buckle fracture lines are pinched together so tightly that chips have been broken from the rock along the break. Also, several new fractures controlled somewhat by joints which strike S. 70° W. and S. 40° E., have opened. The most prominent fracturing is parallel to the joints along the north side of the stream bed. Here several blocks have been ripped out and moved down stream. The entire limestone floor of the stream bottom (60 ft. X 30 ft. X 1 ft.) has been slightly shifted and freshly cracked.

From the field evidence, it is difficult to explain how floodwaters alone could account for the displacement and fracturing. It is postulated that floodwaters backing up behind the bridge and road grade increased velocity of the water immediately west of the bridge. Force by impact was exerted upon the frontal edges of limestone blocks exposed over a gentle warp in the creek bottom (3). Frictional drag of the torrent over the limestone would have the power to transport, dependent upon depth of water and

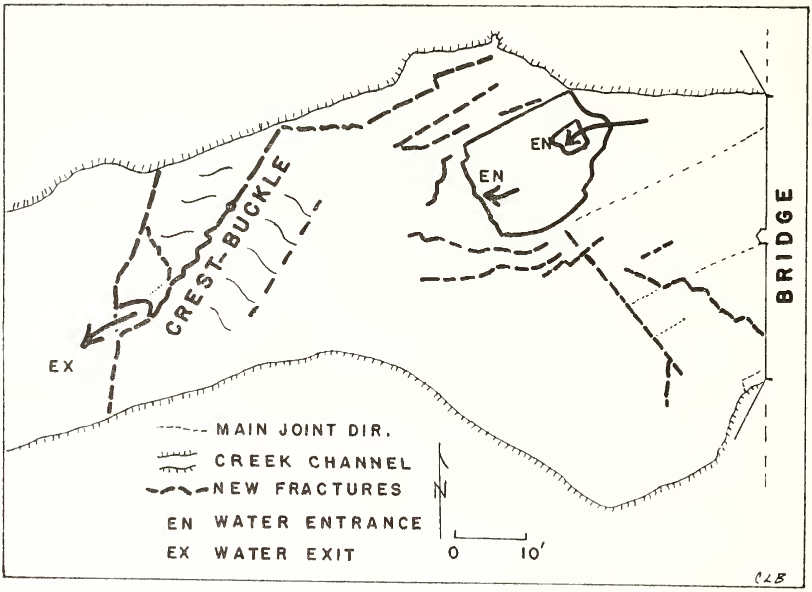

Fig. 1. Plan view of a portion of the rock channel of Little Limestone Creek.

slope of stream (critical tractive force). Also differing velocities between top and bottom of the turbulent current would create variation of pressure with resulting hydraulic lift. Any one or combination of the above could account for transport of blocks of limestone. Some blocks 2 ft. X 3 ft. X 1 ft. were transported several feet to as much as 50 ft.

More difficult to explain, however, is the fracturing of the limestone floor and the formation of the prominent buckle. Force to accomplish this could not come from the torrent alone (1).

The block of limestone (60 ft. X 30 ft. X 1 ft.) which has been disturbed has a dry weight of approximately 140 tons. This block is jointed but shows fresh fractures over most of the surface. If buoyed up by surrounding water the weight would be reduced to 80 or 90 tons. To this, however, must be added the pressure of the floodwater over the block. This stream of water was about 5 ft. deep. Thus it is necessary that a hydraulic force from beneath the limestone act in order to accomplish the buckle, and to lift the rock in other places differentially to cause the fracturing (4).

It is postulated that the necessary hydraulic forces may have come from floodwaters filling pipes or solution channels fed from sinkholes on uplands nearby. These channels may have connected with an area beneath the upper limestone beds of the stream bottom. As the head increased with continuing rain, and the areas affected with this hydraulic force spread, the limestone was broken, and at one place buckled. Thus even before the floodwater gathered appreciably, much of the disturbance to the limestone of the creek bed had occurred.

In conclusion, these observations suggest that at least some of the break-up in limestone creek channels is accomplished by heavy downpours filling solution channels, building up sufficient head to force the rock up from below. The broken rock then falls prey to the rising flood waters.

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