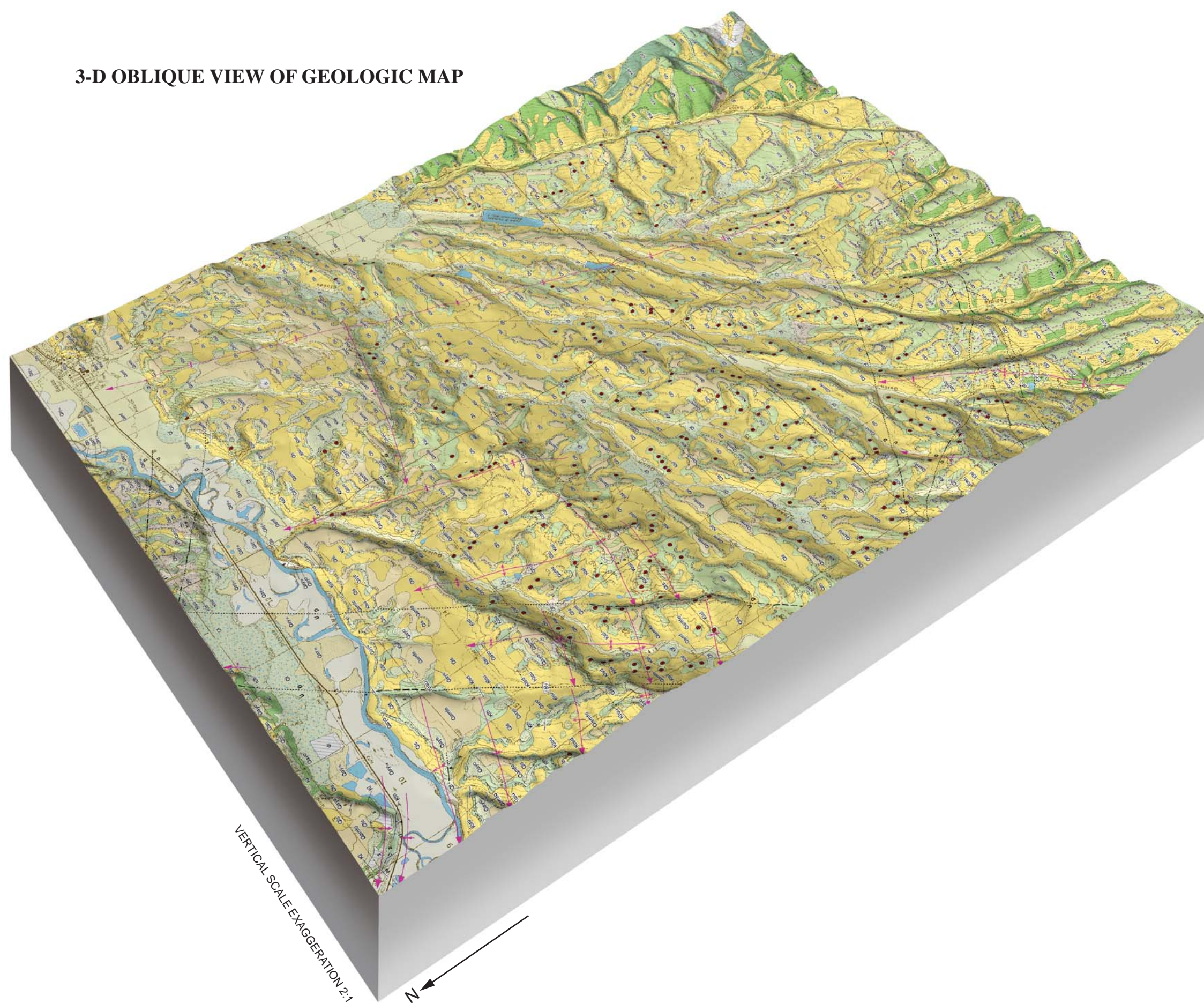
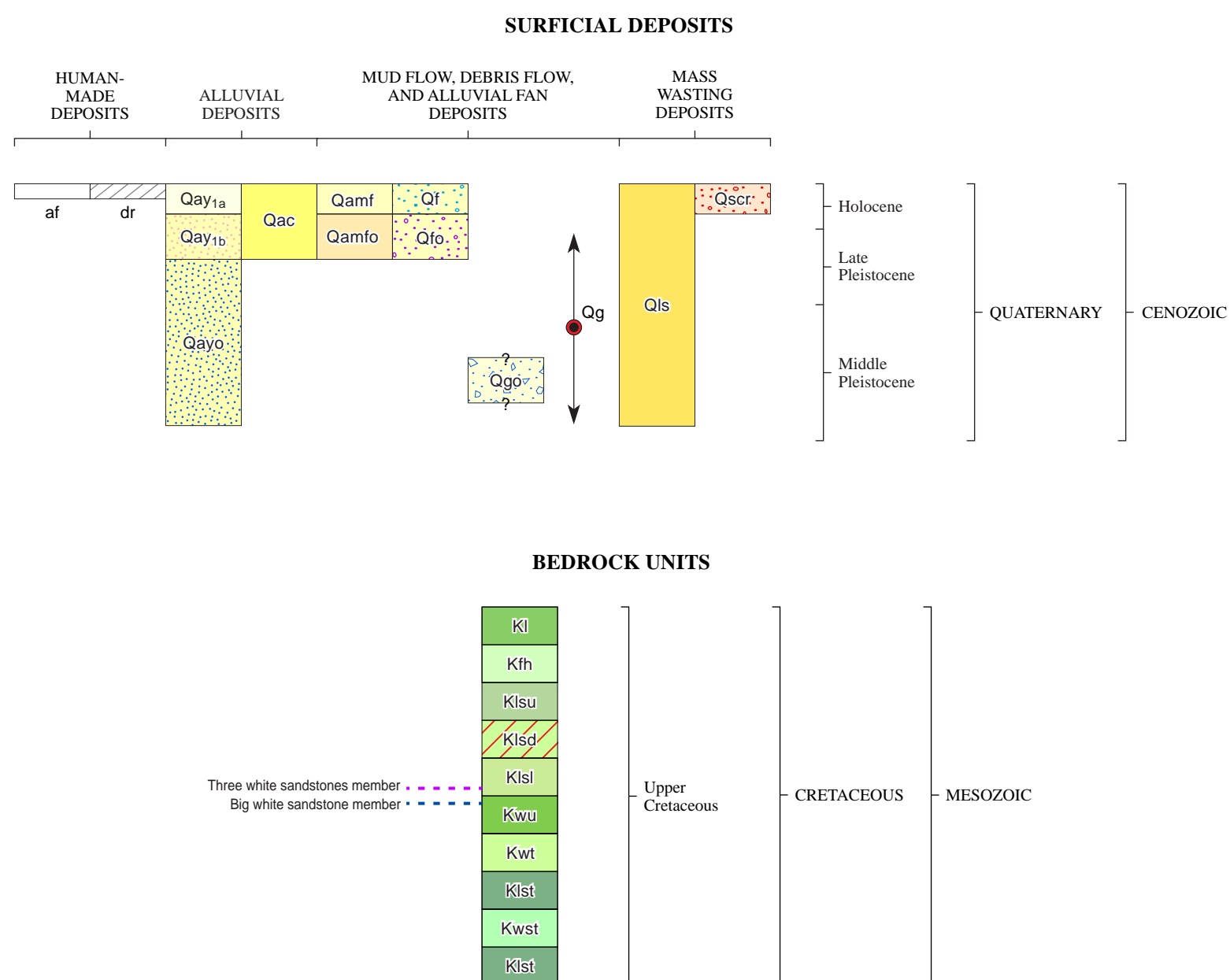


3-D OBLIQUE VIEW OF GEOLOGIC MAP



The Hayden quadrangle contains three structural features of note: (1) the Williams Fork Mountains in the southwestern corner; (2) the Sage Creek anticline in the southeastern corner; and (3) the Sand Wash Basin in the northern half. Sedimentary strata in the Williams Fork Mountains and Sand Wash Basin generally dip toward the north-northeast, while strata on the western flank of the Sage Creek anticline generally dip toward the west and northwest. These structural uplifts, basins, and folds are interpreted to be compressional features of Laramide age (Dickinson and others, 1988). Superimposed upon those features on the western side of the quadrangle are a series of small faults, anticlines, and synclines. They occur along two, roughly orthogonal axes, trending NNE-SSW and WNW-ESE. We interpret that the folding may be Laramide in age and caused by movements of basement sub-blocks during the formation of the main structural features. The faulting appears to be younger. The faults appear to be normal faults that cleanly cut across strata with no associated folding. The most prominent fault is the 1000-foot extension in Colorado, associated with a normal fault in the regional uplift and rift (Chapin and Cather, 1994). In general, fault exposures are rare within the quadrangle. We relied upon geomorphic relationships in placing and extending the inferred fault traces. The faulting is more pronounced in the adjacent Breeze Mountain quadrangle to the west (Barkman and others, 2015). It was nearly impossible for us to obtain strike and dip readings from outcrops of the Lewis Shale, due to grass cover and the deeply weathered nature of the formation.

Coal has been mined in the area for over 100 years, and numerous investigations of the coal resources have been conducted (Fennemore and Gale, 1906; Bass and others, 1955; Brownfield and others, 1999; Johnson and others, 2000; Carroll and others, 2003). The focus of historic underground mining was in the vicinity of Dry Creek, along the hogback ridges of the Mesaverde Group flanking the Sage Creek anticline (Carroll and Bauer, 2002). A large strip mine, the Seneca II West, is located in that same area, along the eastern boundary of the quadrangle, and has been reclaimed. Limited mining is reported from the Lance Formation (actually, the Dad sandstone member of the Lewis Shale) near the town of Hayden. Two small oil-and-gas fields are located in the quadrangle: the Pelt gas (northwestern corner) and the Dry Creek (oil; southeastern corner), both of which produce from the Niobrara age-equivalent interval of the Mancosha Shale (Wray and others, 2005). The Dry Creek field has been producing since the 1920s, and has had a long history of production through the Niobrara interval. The target zones are chalk benches. In addition, coal-bed methane production was attempted from the Mesaverde Group coal measures, but with limited success because of high rates of water production (Barkmann, 2011). Sand and gravel have been mined in modern and ancient deposits of the Yampa River (Guinger and Keller, 2002; Keller and others, 2002), in units Qa1a, Qa1b, Qa1c, and Qayo.

There are 50 ground water wells in the Hayden quadrangle (Colorado Water Conservation Board, 2011). A majority of them are domestic wells located within the modern Yampa River valley, which produce from the alluvial sediments at depths of less than 100 feet. A few of the wells are permitted for uses such as irrigation, industrial (coal mine), commercial, and stock tanks. Deeper water wells in the quadrangle (100 to 3,643 feet in total depth) have been drilled into the Mesaverde Group. The most productive ground water aquifers are the Twentymile and Trout Creek Sandstone Members (Robson and Stewart, 1990).

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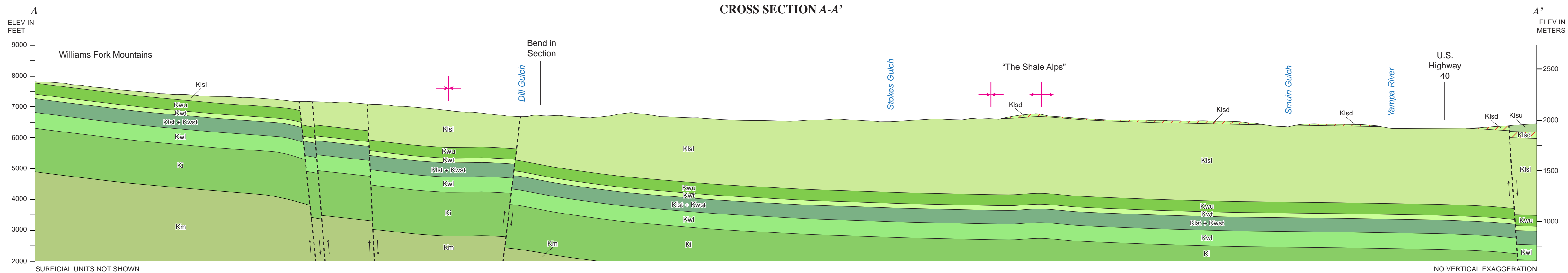
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