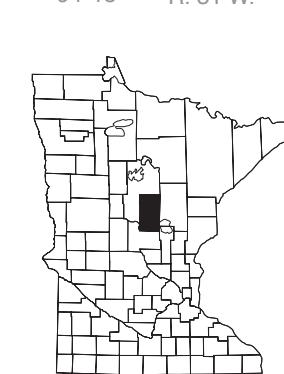


Digital base modified from the Minnesota Department of Transportation Base Data; digital base animation by the Minnesota Geological Survey; Universal Transverse Mercator Projection, grid zone 15 1983 North American Datum



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GEOLOGIC ATLAS OF CROW WING COUNTY, MINNESOTA

BEDROCK GEOLOGY

By

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2004

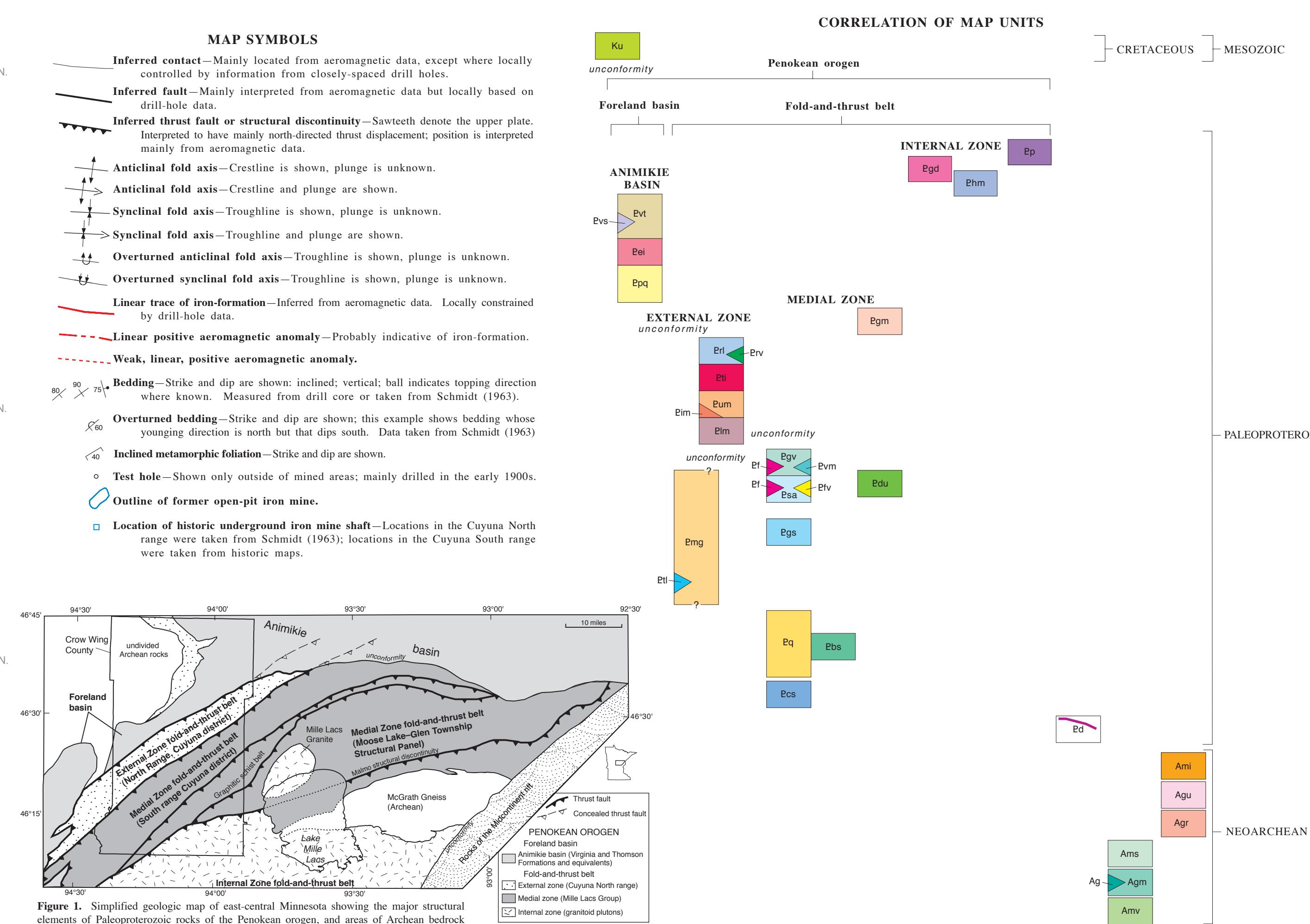


Figure 1. Simplified geologic map of east-central Minnesota showing the major structural elements of Paleoproterozoic rocks of the Penokean orogen, and areas of Archean bedrock (white). Modified from Southwick and others (1998, 2001).

INTRODUCTION

The bedrock beneath Crow Wing County is a diverse assemblage of rock types that are mainly Precambrian (Archean to Paleoproterozoic) in age, along with scattered outliers of much younger Mesozoic sedimentary rocks of Cretaceous age. The county straddles the northwestern border of the Paleoproterozoic Penokean orogen (Southwick and others, 1988) and westward-adjacent Archean rocks. There are no known bedrock outcrops in the county, but concentrated exploratory drilling, coupled with past mining activity, provide a good understanding of bedrock in locations where the hills are many but only scattered drill hole control. Consequently, construction of this map relied heavily on geological interpretation and extrapolation of known geology from surrounding areas into the county.

Crow Wing County contains the Cuyuna mining district, a formerly important source of iron and manganese ore in which production started by underground mining methods and later changed to open-pit methods. The Cuyuna iron range was discovered in 1894, the first ore was shipped in 1911, and the last open-pit mine closed in 1984, during which time over 16 million tons of iron ore were shipped (Skilling's Minnesota Mining Directory, 2001). The Cuyuna range has been informally subdivided into two separate entities—the Cuyuna North range and the Cuyuna South range, based upon contrasting lithological and structural attributes of the iron formation and host rocks.

The portion of this geologic bedrock map that covers the Cuyuna mining district was constructed with reliance on a series of detailed (scale 1:20,000) geological maps by Schmidt (1963). He studied open-pit and underground mines and noted the structural and lithologic necessities of the ore to wallrock. Subsequently, Morey and Morey (1986) completed and modified the Cuyuna range into two entities, the Cuyuna North range and the Cuyuna South range. Consequently, the areas in Crow Wing County where mining or intense exploratory drilling have occurred closely follow the maps by Schmidt (1963) and Morey and Morey (1986). In other areas, the bedrock geology has been variably reinterpreted, based largely on the availability of high-resolution aeromagnetic geophysical data, which were unavailable to earlier workers. Historical records of drilling were compiled from various sources and used as much as possible in the map compilation; however, the lithologic descriptions in these old drilling reports are typically vague and their use is limited largely to identifying the presence of iron-forming minerals.

GEOLOGIC HISTORY

Sedimentary rocks of Cretaceous age were deposited roughly 65 to 100 million years ago over a broad area of Minnesota that extended far to the west of the western end of the Mesabi Iron Range. Subsequent erosion has removed most of these strata, leaving only scattered outliers, which in Crow Wing County have been identified locally as drill hole data. The Cuyuna (1984) suggested that the Cuyuna rocks in Crow Wing County are related to the Cederline Formation, which was deposited along the western Mesabi Iron Range, northeast of Crow Wing County. Bolin's (1958) study of Cretaceous strata from a drill core in Crow Wing County described gray shale, sandy shale, and sand with microfauna of Foraminifera and fish teeth, scales, and bone fragments. Based on this fossil assemblage, Bolin interpreted the Cuyuna rocks as being deposited in a shallow marine environment.

Most of Crow Wing County is underlain by Precambrian bedrock that ranges in age from Archean (approximately 2.700 million years of age) to Paleoproterozoic (approximately 2,200 to 1,800 Ma). The Archean rocks that underlie the northwest portion of the county are poorly understood due to lack of drill hole or outcrop data. However, this part of the county is believed to be part of the Archean "greenstone" terrane, which is well exposed in the western Mesabi Range. It can be extended into the county by the use of geological imagery. In Crow Wing County, these include greenstone belts made up predominantly of metamorphosed mafic volcanic rocks, but include metamorphosed gabbros recognized in drill core and iron-formations inferred from linear aeromagnetic data. The greenstone belts are separated by several belts of metamorphosed sedimentary rocks.

Paleoproterozoic rocks in Crow Wing County are of the Penokean orogen, a term that refers to the large-scale mountain building event that occurred during the Paleoproterozoic in a broad region that includes the Great Lakes and the Appalachians. The Penokean is divided into two subterranea—the fold-and-thrust belt and the foreland basin.

The geologic evolution of the Penokean orogen fold-and-thrust belt involved deposition of sedimentary and volcanic rocks within a poorly understood basin as a result of extension, thinning, and sagging of the preexisting Archean crust. Faults that would have developed during this extensional phase may have provided conduits for magmas to work their way to the surface. The portion of the orogen that is exposed in the fold-and-thrust belt (Fig. 1) is a thick, scaly, and blocky mass of rocks or emplaced as hypabyssal (shallow-level) mafic intrusions. These faults, too, which likely contributed to a complex basin topography, producing local sub-basins within the larger basin, and may have provided pathways for hydrothermal fluid (heated ground water) circulation.

After extensional basin development, the rocks underwent a compressional phase of deformation, the Penokean orogeny, which can also be called as basin closure. This orogeny involved the thickening of the basin margin, and the basin margin moved to varying degrees between roughly 1,900 and 1,760 Ma, during a protracted episode of deformation referred to as the Penokean orogen (Southwick and others, 1988). In east-central Minnesota, the Penokean is divided into two subterranea—the fold-and-thrust belt and the foreland basin. The Cuyuna (1984) noted that the Cuyuna Iron Range is a thrust belt.

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