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# BEDROCK PALEOTEMPERATURE STUDY OF THE KENTLAND IMPACT SITE KENTLAND, INDIANA

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ABSTRACT: Conodont samples were collected from exposed strata in the Kentland Quarry to determine the thermal effects of an impacting body. A meteorite impact, such as proposed by Deitz (1947), should cause alteration of the conodont elements, especially those near the point of impact. Most of the Ordovician through Silurian elements recovered thus far are pale yellow and match the conodont alteration index (CAI) of 1.0 (Epstein, Epstein, and Harris, 1977). However, some elements recovered from the basal Silurian (Sexton Creek Limestone) have a CAI of 3.0. These results are similar to those of Votaw (1980) and suggest that only minor, if any, thermal alteration of the conodonts occurred as a result of the formation of the Kentland structure.

KEYWORDS: Conodonts, meteorite impact, paleotemperature.

## INTRODUCTION

Located about 100 miles south of Chicago, the Kentland structure is exposed in the Newton Stone Company Quarry 2.5 miles east of Kentland, Indiana (Figure 1). The debate on the origin of the Kentland structure has lasted for more than a century (Gorby, 1886; Deitz, 1947; Tudor, 1971; Laney and Van Schmus, 1978). The structure has been called a Silurian reef (Gorby, 1886). Tudor (1971) claimed an endogenetic origin. However, no igneous rocks are present in the open quarry, and none has been found by coring operations. Shatter cones at the site suggest a meteorite impact origin. If the strata are rotated to their original position, the shatter cone apices point toward the sky (Dietz, 1947). If the site is compared with morphological and structural analogs produced by explosion cratering, the structure falls into the flat-floored, central-uplift crater type (Roddy, 1977). On comparing Kentland with other well-studied impact sites (e.g., Flynn Creek (Roddy, 1968, 1977), Wells Creek (Wilson and Stearns, 1968), and Decaturville (Offield and Pohn, 1977)), many structural and geophysical similarities are noted. At present, the quarry operation has exposed a 100,000 square meter area on the northwestern flank of the central uplift (Figure 2).

Ongoing studies (Nasser and Howe, 1993) are underway to determine the thermal effects of the meteorite on the conodonts at the Kentland impact site. The color alteration index (CAI) of Epstein, Epstein, and Harris (1977) was used to determine whether or not the conodonts had been thermally altered. The CAI value may range from 1 to 8. The higher numbers indicate that higher temperatures had been reached sometime after the deposition of the conodonts. The conodonts at Kentland should display significant alteration as a result of the heat generated by the meteorite impact.

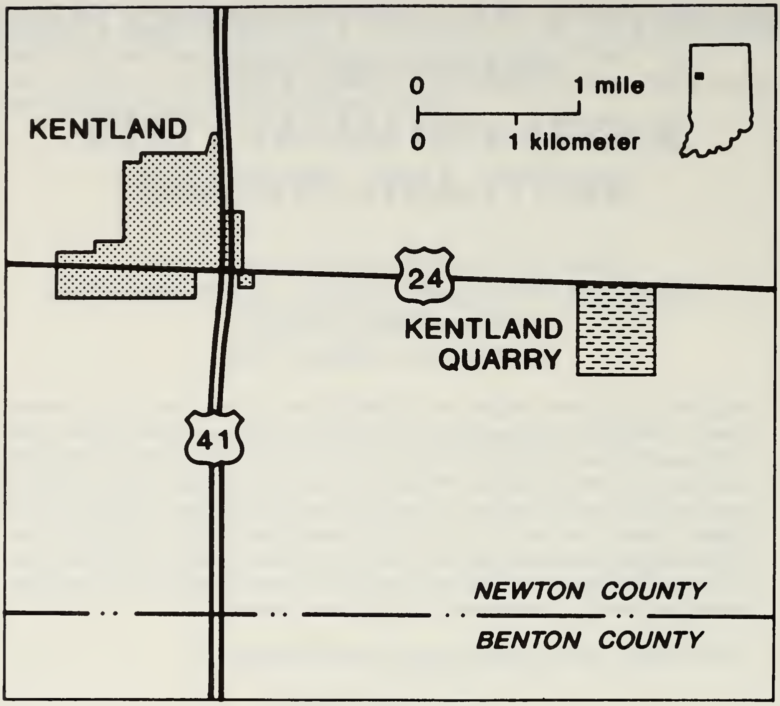


Figure 1. Location of the Kentland Quarry.

## GEOLOGIC SETTING

About 50 different quarries are operating in Upper and Middle Silurian rock in northwestern Indiana and northeastern Illinois. The Kentland Quarry (Figure 2) is located in a complete sequence from the Lower Ordovician (Shakopee Dolomite) through Lower Silurian (Salamonie Dolomite) (Gutschick, 1983). The rocks at Kentland have been uplifted at least 700 m. The overall structure is approximately 12.5 km in diameter (Laney and Van Schmus, 1978). This tremendous uplift is an example of the effect of the enormous kinetic energy released by a large meteorite impact.

In general, northwestern Indiana has remained geologically stable for millions of years. The strata in most of Indiana are gently dipping and appear nearly horizontal to the naked eye (except in areas where the bedrock is draped over Silurian reefs). Indiana has a few isolated locations where conodonts have been altered to as high as CAI 6.0 (Harris, Rexroad, Lierman, and Askin, 1990). In Newton County, however, CAI values of 1.0 have been reported in the eastern part of the county (Rexroad and Droste, 1982). These low CAI values suggest the absence of other causes of conodont alteration, making the Kentland Quarry an excellent setting for testing whether or not meteorite impact affects conodonts.

At Kentland, because of the chaotic strata, the strike of the rocks depends on the block being studied. Generally, on the north and south flanks of the dome, the strikes are east-west, whereas on the east and west flanks of the dome, the

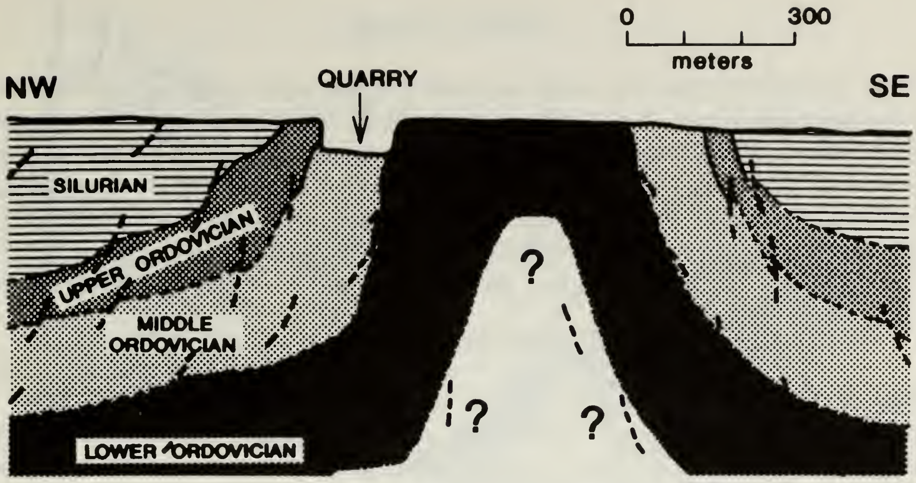


Figure 2. Location of the Kentland Quarry in the central uplift. The peak has been eroded (modified from Laney and Van Schmus, 1978).

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strikes are north-south. The dips at the Kentland structure also vary markedly, ranging from 38 degrees to overturned bedding (Figure 3).

## METHODS

**Field Work.** Samples of the Ordovician and Silurian units were taken across the structure to study the stratigraphic distribution of thermal activity. The approximate location of each sample was recorded on the geologic map prepared by Gutschick (1983). At each sample site, at least 10 kilograms of rock were collected, because quarry activity could destroy or cover up sample sites and prohibit later sampling. Ordovician (Shakopee Dolomite) samples were taken from the south-central part of the quarry. Additional Ordovician samples were taken along the west wall from a 6-foot thick dolomite member (Fort Atkinson Limestone) situated in the middle of the Maquoketa Shale. Silurian samples were also taken along the west wall of the quarry, because this wall was the only area where Silurian rocks were exposed. The Silurian units sampled were the Sexton Creek Limestone and the Salamonie Dolomite. Within these two formations, 17 different samples were collected at ten foot intervals.

**Laboratory Work.** Laboratory procedures were adopted from Kummel and Raup (1965). Ten percent aqueous glacial acetic acid was used to dissolve the samples. Instead of using bromoform (heavy liquid separation), the authors washed the conodonts in a set of sieves (2.5 phi, 3.0 phi, and 4.0 phi) to separate the processed rock fragments by size. Most conodonts were retained on the 3.0 phi sieve.

## RESULTS

The Ordovician (Shakopee Dolomite) samples contained no conodonts or any other microfossils. Conodonts from the Fort Atkinson Limestone had a CAI of

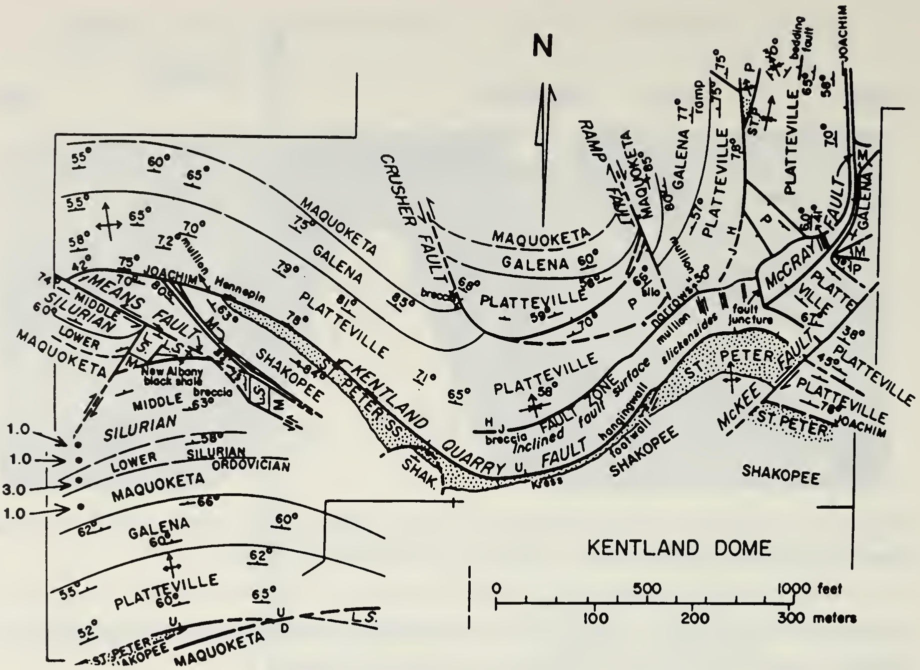


Figure 3. Geologic map of the Kentland Quarry (modified from Gutschick, 1983). Sample sites with CAI numbers are shown on the west side of the map.

1.0. From the Silurian, samples 4, 5, and 17 were processed, and all contained conodonts. The CAI values for these samples were: for sample 4, 1.0; for sample 5, 1.0; and for sample 17, 3.0. Samples 4 and 5 were from near the middle of the Salamonie Dolomite; and sample 17 was from the basal Sexton Creek Limestone near the Ordovician-Silurian contact.

## DISCUSSION

The CAI values were plotted on the geologic map at the sample sites (Figure 3) to show the stratigraphic distribution of the thermal alteration as well as its horizontal distribution across the quarry. The variation pattern of the CAI numbers was unexpected, but its relationship with the thermal conductivity of the rock soon became apparent. Votaw (1980) sampled the Middle Ordovician Platteville and Galena Dolomite units and reported CAI numbers of 1.5. These data indicate that the massive dolomites situated on the northwest flank of the central uplift beneath the original flat-floored crater (which has been eroded away) acted as insulators. The shales interbedded with dolomites in the basal Silurian (Sexton Creek Limestone) may have conducted away some of the heat generated within the bedrock better than the dolomites. The authors plan to follow up this report with the CAI values obtained from sampling faults in the quarry and the Maquoketa Shale (i.e., Brainard Shale). A broader sampling across the quarry may provide greater insight into how heat was transmitted through the disturbed bedrock.

## CONCLUSIONS

The data collected from the Kentland site show isolated thermal alteration beneath the crater floor. Most of the thermal energy was apparently dissipated by vaporization of the ejecta blanket and formation of the breccia lens along with minor thermal alteration of the target material within the structurally complex rocks beneath the crater floor. Comparative studies planned for Wells Creek and Meteor Crater may reveal how heat is transmitted through rocks at meteorite impact sites.

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