THE GEOLOGY OF KLEIN AND CONKLIN QUARRIES, JOHNSON COUNTY, IOWA

edited by
Thomas Marshall and Chad Fields

Geological Society of Iowa

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Cover Photograph

Geologists and quarry employees examine a Pennsylvanian sinkhole, developed in limestones of the basal Solon Member (Little Cedar Formation) and Davenport Member (Pinicon Ridge Formation) at Klein Quarry. This sinkhole yielded spectacular calcite crystals and other mineral samples that are discussed in this guidebook.

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A PALEOMAGNETIC REVERSAL WITHIN THE PRE-ILLINOIAN ALBURNETT FORMATION, EASTERN IOWA

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ABSTRACT

The Matuyama-Brunhes reversal (0.78 Ma) is a paleomagnetic datum within the pre-Illinoian stratigraphic sequence of the North American midcontinent that marks the boundary between the Early and Middle Pleistocene. In eastern Iowa this datum separates Wolf Creek Formation deposits with normal remanent polarity from older glacial diamictons of the Alburnett Formation with reversed polarity.

In this study additional magnetic characterization of the Alburnett Formation was accomplished by systematically sampling sediments of various facies exposed in Conklin Quarry, including till, valley-fill alluvium, and valley-slope colluvium. Direct age control on Iowa tills was also obtained from cosmogenic isotope dates of tills at the quarry.

Two Alburnett Formation tills have reversed detrital remanent magnetization. In contrast, younger locally preserved Alburnett Formation valley-fill and valley-slope sediments inset into the reversely magnetized tills and capped by the Westburg Geosol, have normal detrital remanent magnetization. Therefore, a reverse-to-normal polarity change occurred during the latest phase of Alburnett Formation deposition in eastern Iowa. Nevertheless, cosmogenic isotope dates for tills at Conklin Quarry and elsewhere show that the Alburnett Formation and its equivalents are ~1.3 Ma in age. Therefore, the reversal within the Alburnett Formation cannot be the Matuyma/Brunhes transition. Instead, this reversal most likely reflects the Cobb Mountain Normal Polarity Subchron, (c. 1.2 Ma), which is within error limits of cosmogenic isotope dates for the Alburnett tills and their equivalents.

INTRODUCTION

The Matuyama-Brunhes (M/B) paleomagnetic reversal at 0.78 Ma is a regional datum within the pre-Illinoian glacial sequence of the North American midcontinent (Easterbrook and Boellstorff, 1984; Rovey and Kean; 1996, 2001; Roy et al., 2004). Throughout the region three normal-polarity tills and associated sediments overlie multiple tills with reversed remanent polarity (Fig. 1). Based on fission-track dating of tephra in western Iowa and cosmogenic-isotope burial dating in northern Missouri, the normal-polarity tills are younger than the M/B boundary, whereas the reversely magnetized tills are older. Therefore, this paleomagnetic datum is the M/B reversal, which is the new boundary between the Early and Middle Pleistocene (Gibbard et al., 2010). Rovey and Kean (2001) further suggested that this reversal followed shortly after the maximum expansion of the second major pre-Illinoian glaciation that is recorded widely in the midcontinent of North America. Here we present evidence from Conklin Quarry that this second major glaciation actually is significantly older than the M/B reversal, but did occur shortly before a brief reversal of the earth's magnetic field.

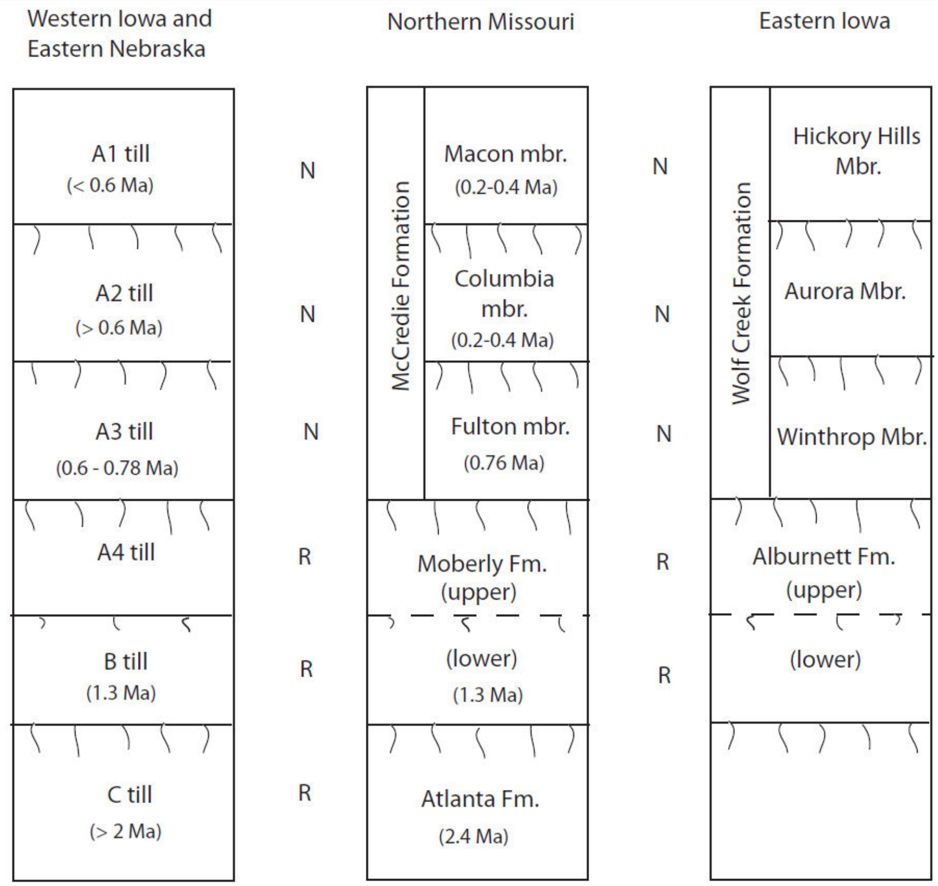


Figure 1. Pre-Illinoian glacial and paleomagnetic sequence, eastern & western Iowa, northeastern Missouri. Stratigraphic units are mostly till. "N" denotes normal magnetic remanence; "R" denotes reversed magnetic remanence. Member divisions in northern Missouri remain informal. Bounding ages for the tills in western Iowa are based on fission-track dates of interbedded tephras (Boellstorff, 1978; Richmond and Fullerton, 1986). Ages in northern Missouri are cosmogenic isotope burial dates; see Balco and Rovey (2008, 2010) for methodology and error limits. The age for the Fulton member is "tuned" to dates for Marine Isotope Stage 18, based on its normal magnetic remanence. The range in ages for the Macon and Columbia members reflects large and overlapping error limits for those units. Stratigraphy for eastern Iowa is from Hallberg (1980).

LOCATION AND STRATIGRAPHY

Conklin Quarry exposes the most complete documented pre-Illinoian glacial stratigraphic section in the continental interior (Hallberg *et al.*, 1984; Kemmis *et al.*, 1992). At various times this quarry has exposed six tills assigned to two formations and various members (Figure 1). The oldest two tills here are grouped within the Alburnett Formation, which is the oldest formally defined glaciogenic deposit in eastern Iowa. Nevertheless, deposits of at least one Quaternary glaciation which predates the Alburnett are widespread throughout the Midwestern U.S. (Figure 1; Hallberg, 1986; Balco et al., 2005); thus, the Alburnett Formation marks the second major Quaternary glaciation.

Three lithofacies are present within the Alburnett Formation at Conklin Quarry (Figure 2). The lowermost diamicton (till) in the Alburnett Formation directly overlies striated Devonian limestone. This unit is an oxidized, unleached, clast-rich, matrix-supported, sandy loam diamicton. Thin (<30 cm) discontinuous pods of fossiliferous peat and/or organic-rich silt (an A horizon) overlie a 20-30 cm-thick reduced weathering profile developed in the diamicton. Oxidation of the diamicton (below the reduced weathering profile) is probably related to the relatively porous sandy loam texture and position atop fractured carbonate bedrock, rather than to subareal weathering. We interpret the peat and silt to represent a minor stade in the overall main phase of Alburnett glaciation. This interpretation is supported by fossil fauna within the peat indicative of a full glacial environment (Baker et al., 1984), and by low cosmogenic-isotope concentrations within the pedogenically altered silt (Balco and Rovey, 2010). The weathered zone, the silt, and the peat are overlain by a second Alburnett Formation till, an unoxidized, unleached, matrix-supported loam diamicton.

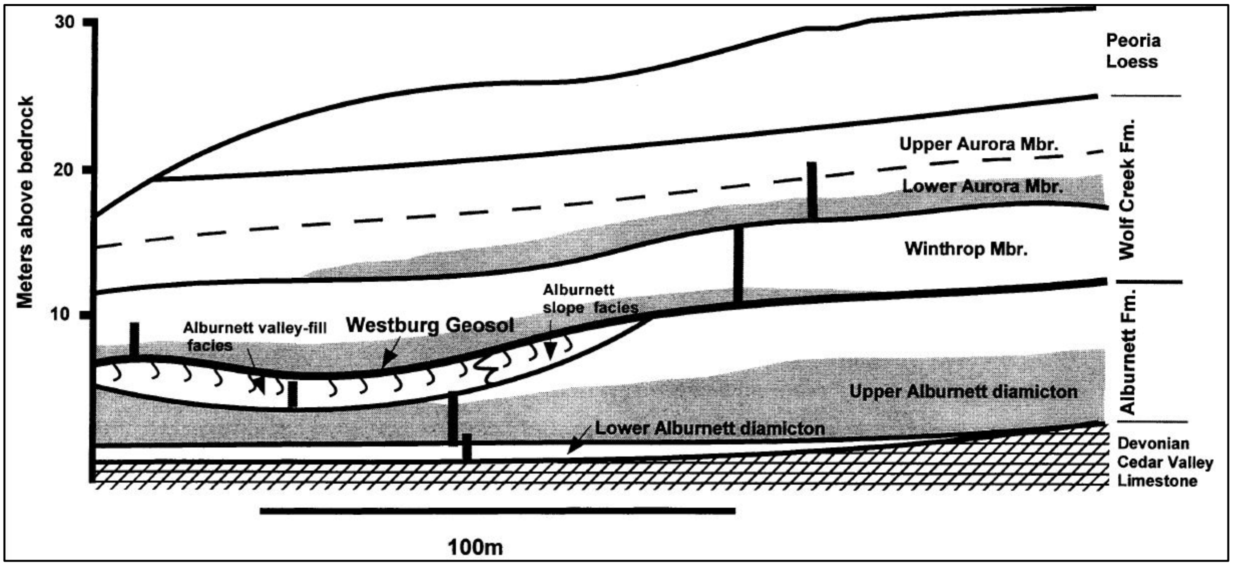


Figure 2. Quaternary section exposed at Conklin Quarry. All units beneath the Peoria Loess are pre-Illinoian in age. Gray shading indicates unoxidized zones. Vertical bars show locations of sampling transects.

A fluvial erosion surface cuts across the upper Alburnett till and defines the southwestern wall of a broad buried paleovalley (Hallberg et al., 1984; Kemmis et al., 1992; Figure 2). This erosion surface is buried by valley-fill (alluvial) and slope (colluvial) deposits of the Alburnett Formation. The valley-fill deposits generally fine upward from basal gravel to sandy clay loam. The Westburg Geosol (an A-Btg-BCg profile at this location) is developed in the upper part of the valley-fill deposits (Hallberg et al., 1984; Kemmis et al., 1992). Slope deposits consist of a basal stone lag that is overlain by loamy diamicton. The lower part of the slope deposits includes zones of weakly graded bedding; in places upper portions are pedogenically altered to a Bt-BC profile of the Westburg Geosol. This soil profile grades downward to a 4 m-thick, oxidized and leached to unleached, weathering profile developed in the underlying slope sediments and glacial diamicton. The slope deposits interfinger with, and grade into, the valley-fill deposits along the paleo-footslope. The presence of well-expressed soil horizons in the valley-fill and slope sediments, and an associated oxidized weathering zone beneath the slope deposits indicate that the Westburg Geosol is of interglacial rank (Follmer, 1983; Bettis, 1998).

The valley-fill and slope sediments in which the Westburg Geosol developed are included in the Alburnett Formation, based on mineral composition and soil stratigraphy (Hallberg, 1980; Hallberg et al. 1984; Kemmis et al. 1992). The weathering profile that developed in the upper Alburnett Formation till beyond the channel margins cuts across the slope and valley-fill sediments without diminution. Moreover, the Westburg Geosol preserved atop the valley-fill sediments is one of the best-expressed and most-mature examples yet encountered and by inference developed during most of the interglacial time between deposition of the Alburnett and Wolf Creek Formation tills. Therefore, the well-expressed Westburg Geosol atop the valley-fill and slope sediments indicates that they are much closer in age to the underlying Alburnett Formation till than to overlying till of the Wolf Creek Formation.

Wolf Creek Formation glacial deposits are also present in the paleovalley incised into Alburnett Formation sediments. Only the two older members of the Wolf Creek Formation were accessible during this study. The Winthrop and Aurora Members (Figures 1and 2) are dominantly massive, matrix-supported, loam glacial diamictons with varying degrees of shear and deformation structures.The Winthrop Member, in particular the lowest meter, is intensely sheared. Distinct block inclusions and debris bands of remobilized Alburnett Formation sediment are also present near the base and locally are deformed into fold structures. In the paleovalley, lower portions of the Winthrop are unoxidized and unleached, and the lower portion of an oxidized weathering profile is developed in the upper part of the unit. Beyond the margin of the paleovalley, the oxidized and unleached weathering zone extends through the entire thickness of the Winthrop Member and into the underlying Alburnett Formation.

A glacial erosion surface separates oxidized Winthrop Member till from overlying unoxidized till of the Aurora Member. The Aurora Member of the Wolf Creek Formation is comprised of two glacial diamictons that are separated by a sharp till-till contact in part of the exposure, and by discontinuous lenses of stratified sediment elsewhere along the outcrop (Figure 2).

PREVIOUS WORK

Conklin Quarry

Baker (1985) and Baker and Stewart (1984) established the polarity sequence of pre-Illinoian tills in eastern Iowa (Figure 1), largely based on samples collected at Conklin Quarry. This work confirmed that the M/B reversal is an important datum in the pre-Illinoian glacial sequence, and it was later helpful in establishing the temporal equivalence between the Alburnett Formation in eastern Iowa and the Moberly Formation in northern Missouri (Rovey and Kean, 1996; 2001).

Baker (1985) isolated the remanent magnetic polarity of a large number of specimens cored from block samples of each pre-Illinoian stratigraphic unit (Table 1). The remanent directions of individual specimens from some blocks are somewhat scattered, but the polarity of each unit is clear. Each till within the Wolf Creek Formation has normal remanent polarity, whereas the older Alburnett Formation tills and intratill silts have reversed polarity. In western Iowa ages of the tills are bracketed by fission-track dates of interbedded tephra, and in northern Missouri a similar till sequence has been dated by the cosmognic-isotope burial dating method (Balco and Rovey, 2008; 2010). The normal-polarity tills are younger than 0.78 Ma and the reversed-polarity tills are older. Based on correlation across these study areas, the change in polarity between the Alburnett (reversed) and the Wolf Creek Formation (normal) must reflect the M/B reversal (Figure 1; Hallberg, 1986).

Table 1

Unit	Sample	n	Inclination	Declination	κ	alpha 95	Polarity
Aurora (upper till)							Normal
	Au4.2	9	+27	342	2.9	33	
	Au3.9	11	+29	345	6.8	19	
	Au3.2	17	+43	260	1.6	45	
	Au2.2	9	+56	295	3.3	34	
Winthrop							Normal
	Wn2.1	13	+43	49	2.5	49	
	Wn0.4*	24	+62	0	2.8	22	
Alburnett (upper till)							Reverse
	Abt2.4	12	-24	137	8.1	22	
	Abt0.9	22	-24	152	6.5	13	
(intratill silt)	Abs	14	-37	180	47	6	Reverse
Moberly (Missouri)		3** Sites	-38	194	7.6	29	Reverse

* Block sample collected from nearby Kline Quarry 5 km south of Conklin Quarry.

** Means are the site averages from 16 individual measurements, each with a highly significant characteristic remanence based on principal component analysis.

Table 1. Summary of previous paleomagnetic measurements. Iowa results are based on specimens from large sample blocks (Baker, 1985). All but one sample block were collected in Conklin Quarry. Missouri results are from Rovey and Kean (2001). Table omits results from a highly sheared and deformed interval at the base of the Winthrop Member having essentially random orientations. "n" is the number of specimens measured, " κ" is the Fisher precision parameter, and "alpha 95" is the 95% confidence limit (degrees).

Northern Missouri

The Moberly Formation in northern Missouri is laterally continuous with the Alburnett Formation in eastern Iowa (Figure 1, Rovey and Tandarich, 2006). These two units have a similar lithology and both retain a reversed remanent magnetic polarity with shallow inclination (Table 1). Rovey and Kean (2001) interpreted the regionally persistent, shallow, reversed inclinations in the Alburnett Formation and its equivalents as evidence for deposition during the latest part of the Matuyama Reversed Polarity Chron. Shallow, in some cases oscillating, inclinations typify the latest phase of a polarity interval for several thousand years prior to a complete reversal (e.g. Opdyke and Channell, 1996). However, recent cosmogenic-isotope burial dates for the Missouri section, (Table 2, Balco and Rovey 2008; 2010) show that the age of the Moberly Formation (Missouri) is approximately 1.3 Ma. Likewise the lithologically similar "B" till in western Iowa overlies a tephra that is dated at 1.3 Ma in one core (Boellstorff, 1978). We examined this core and found that this tephra is present immediately below the "B" till within an unweathered silt. Thus, the age of the "B" till appears to be close to 1.3 Ma as well, and the shallow inclinations within these tills cannot reflect the onset of the M/B transition at 0.78 Ma.

Table 2

State	Stratigraphic Unit	Age	Number Of Sites
Missouri	Macon	0.21 +/- 0.18 Ma	1*
	Columbia	0.22 +/- 0.16 Ma	2
	Fulton	0.80 +/- 0.06 Ma	3
	Moberly	1.31 +/- 0.09 Ma	2
	Atlanta	2.42 +/- 0.14 Ma	2
Iowa	Winthrop	0.72 +/- 0.37 Ma	1
	Alburnett	0.87 +/- 0.43 Ma	1

* Samples at a second site give an age of < 0.18 +/- 0.5 Ma for the Macon.

Table 2. Cosmogenic-isotope burial ages for tills in northern Missouri and Conklin Quarry, Iowa (Balco and Rovey, 2008 & 2010). See Figure 1 for the rank of stratigraphic units. Ages in Missouri are error-weighted means from multiple sites; the age at each individual site is determined from 2-6 individual isotope-ratio measurements.

PROCEDURES

Paleomagnetics

We collected samples from Conklin Quarry and measured their paleomagnetic remanence in 1997 and 1998. Samples were collected in vertical sequence from fresh exposures by inserting oriented plastic boxes vertically downward on a surface that had been cleaned and leveled by hand in fresh, moist, and undisturbed sediment. All samples from the Alburnett valley-fill and slope sediments were taken from below the upper paleosol that developed in these deposits. Samples were then subjected to stepwise alternating field (AF) demagnetization to clean the magnetic remanence, primarily by removing viscous remanence (VRM) acquired in the current field.

Cosmogenic Isotopes

In 2007 we collected additional samples from the Westburg Geosol developed in the upper Alburnett till and the intra-Alburnett paleosol atop the lower Alburnett till. We sieved the medium-coarse sand from these samples and extracted ^{10}Be and ^{26}Al from the quartz grains following procedures in Balco and Rovey (2008). Near the ground surface (i.e. within a weathering profile) these isotopes are produced in a fixed ratio within quartz grains by bombardment of cosmic radiation. After burial, in this case deposition of an overlying till, production (nearly) stops within the buried profile and the isotope ratio changes systematically with burial time due to differential decay. Thus, the ratio of ^{10}Be:^{26}Al within paleosols/weathering profiles gives the length of time that the paleosol has been buried. In this case isotope ratios within the intra-Alburnett paleosol give the age of the upper Alburnett till, and ratios from the Westburg Geosol date the overlying Winthrop Member.

RESULTS

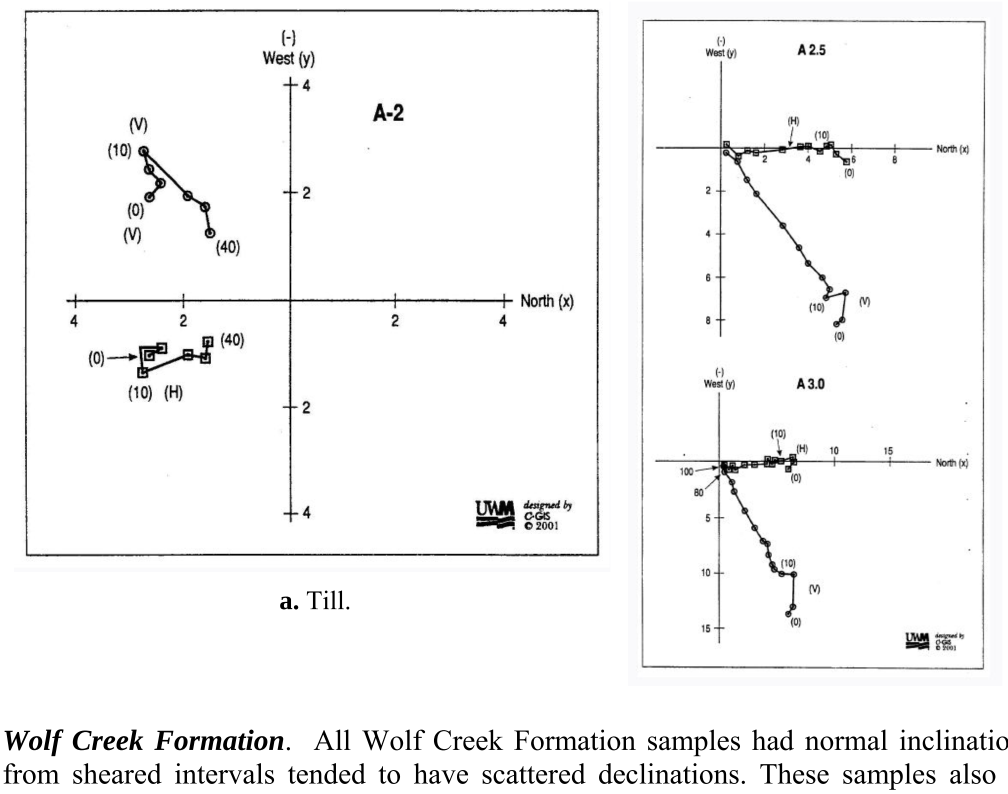
Demagnetization

Alburnett Formation. Samples of Alburnett Formation till had a stable reversed characteristic remanence that is best expressed between 10 and 30 mT of demagnetization (Figure 3a). Alburnett till samples had coercivities ranging generally from 20-40 mT; therefore, the natural remanence should be a detrital remanent magnetization carried by magnetite.

Samples of the upper Alburnett Formation valley-fill silt also had a strong characteristic remanence (Figure 3b), but with normal polarity instead of reversed. Demagnetization of these samples through 100 mT showed a single component of normal magnetization. The Alburnett valley-fill silt samples had coercivities ranging between 25 and 50 mT in most samples, again consistent with a depositional remanence carried by magnetite and inconsistent with any kind of secondary remanence.

Samples from slope deposits of the Alburnett Formation had a weak, in many cases unstable, remanence. Nearly 40% of these samples had intensities which declined to, or closely approached, the magnetometer's lower sensitivity limit (0.05 x 10^{-3} A/m) before reaching the 10 mT demagnetization step (i.e. before any VRM could be removed). Such samples were omitted from further consideration. The remaining slope-deposit samples had normal inclination and mixed declinations.

Figure 3. Vector intensity diagrams, Alburnett Formation. Circles and squares show the vertical and horizontal components, respectively of the magnetic remanence vector upon successive demagnetization steps.



b. Alluvial silt.

a. Till.

Wolf Creek Formation. All Wolf Creek Formation samples had normal inclination, although samples from sheared intervals tended to have scattered declinations. These samples also had lower magnetic intensities and shallower inclinations than other samples within the same respective stratigraphic unit.

The lower intensity is not caused by differences in magnetic mineralogy, because the bulk susceptibility (a measure of total magnetite content) is nearly constant within each respective depositional unit.

Two vertical transects were sampled in the Winthrop Member. The first transect (8 samples) was in an area with minimal shear effects, except near the base. The second transect (4 samples) was in an area exhibiting many shear and deformation structures. Samples from both transects, particularly those from the second, had relatively low NRM, indicating that mechanical stress during or shortly after deposition prevented or disrupted a strongly preferred orientation of magnetic grains.

Polarity and Mean Directions

Alburnett Formation. Optimal "cleaning" or demagnetization levels were obtained for each unit, based on a number of criteria, including the consistency of measured remanence directions in multiple orientations after each demagnetization step. Based on these results, the optimal demagnetization level was approximately 20 mT for Alburnett Formation tills and colluvium, 30 mT for Alburnett silts, and 10 mT for Wolf Creek tills. Declination and inclination values of samples obtained from principal component analysis (PCA) do not deviate significantly or systematically from those obtained at these levels. Therefore, vector-mean values of each stratigraphic unit (Table 3) are calculated from values obtained at optimal demagnetization levels.

Table 3

Unit	n	Inclination	Declination	κ	alpha 95	Polarity	NRM Intensity
Aurora							
Lower Till	3	+65	16			Normal	4.6
Winthrop	12	+71	136	4.5	19	Normal	1.2
Alburnett							
Alluvium	11	+56	350	12.	12	Normal	4.6*
Colluvium	7	+64	213	2.1	37	Normal	1.0**
Upper Till	9	-43	176	2.6	29	Reverse	1.7
Lower Till***	3	-52	172			Reverse	5.5

* omits value from three samples with distinct short-term viscous effects.

** omits value from 5 samples with an unstable remanence.

*** three samples from this unit crumbled during transport to the lab and were discarded.

Table 3. Summary of new paleomagnetic measurements, Conklin Quarry. Table includes results for those units represented by three or more samples. Inclinations and declinations are vector means, "n" is the number of specimens, "κ" is the Fisher precision parameter, and "alpha 95" is the 95% confidence limit (degrees), calculated for units with 7 or more samples. Intensities are median values in 10-3A/m.

Both Alburnett Formation tills have reversed remanent polarity. The vector-mean inclination and declination of the lower till (172º and -52º, respectively) are close to reversed dipole values at this latitude, whereas the upper till has a shallower (-43º) and more erratic inclination. Inclination values in the upper till are consistent with shallow values measured regionally in this unit and its stratigraphic equivalents elsewhere in the midcontinent region (Tables 1 and 3). Baker's (1985) block-mean inclination value of the intratill silt (-37°) is consistent with trends within and between the two Alburnett Formation tills (Figure 4).

In contrast to the reversed polarity of the underlying tills, the alluvial valley-fill silt of the Alburnett Formation has normal polarity. Step demagnetization and PCA analysis isolated no significant reversed components, except for a single suspect sample with a borderline negative inclination. This particular sample was taken from a bioturbated interval and had a weaker magnetization, along with pronounced viscous effects. Overall, declinations and inclinations cluster tightly around normal dipole values (vector means of 350° and +56°, Table 3, Figure 4), albeit with more scatter in the upper 0.6 m. Given that the normal remanence is consistent with a primary detrital magnetization, these results indicate that the alluvial silt in the upper part of the Alburnett Formation was deposited in a normal magnetic field.

Valley-slope sediments (colluvium) from the upper part of the Alburnett Formation also had positive inclinations close to normal dipole values. Declinations, however, were more scattered and tended to be aligned in an east-west orientation, perpendicular to the slope of the paleovalley wall. The fact that these declinations preserved an orientation related to the flow direction is additional evidence that the measured remanence is not merely a secondary post-depositional acquisition. If a secondary magnetic remanence had been acquired through post-depositional processes (e.g. a viscous overprint or a chemical remanence due to growth of authogenic Fe-rich minerals), declinations would consistently align with the dipole field. Therefore, the normal inclinations must have been acquired during deposition and in a normal-polarity magnetic field.

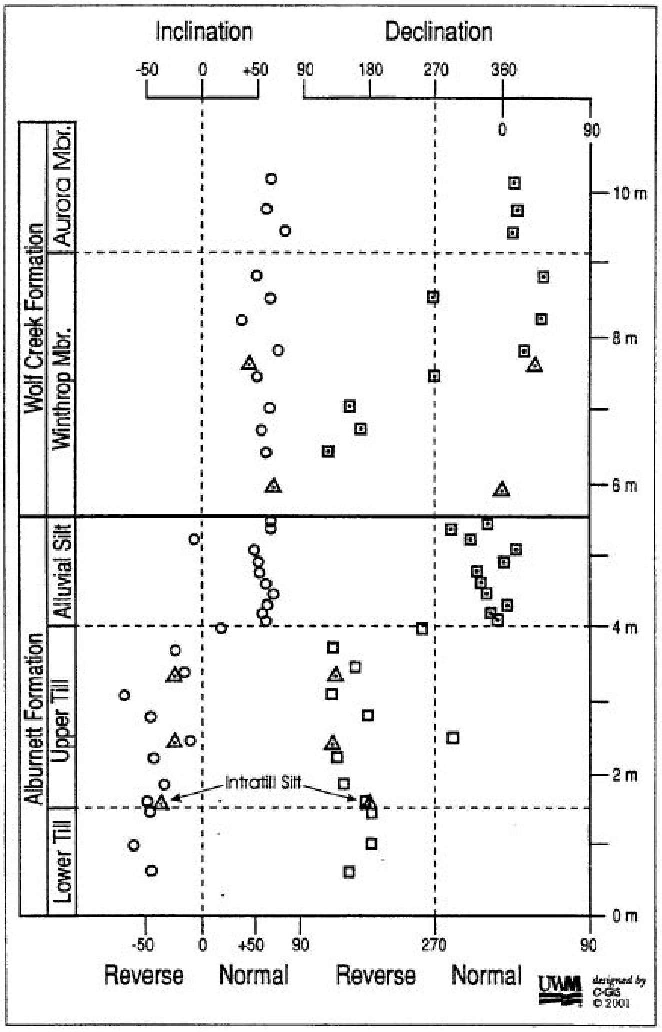


Figure 4. Summary of magnetic polarity measurements, Conklin Quarry. Section shown is a composite of individual transects completed at nearby locations within Conklin Quarry. (see Figure 2). Circles and squares indicate inclination and declination, respectively, measured for this study. Triangle pairs show the average inclination and declination of multiple specimens from large blocks, taken from Baker (1985).

Winthrop Member. Inclinations within Winthrop Member till are also tightly clustered about the normal dipole value (Figure 4), except for samples taken near the base of the second (highly sheared) transect; those inclinations are anomalously low, and the declinations seem to reflect the direction of ice movement during deposition. The vector-mean inclination of +71° (Table 3) for all Winthrop samples is greater than the dipole value of 60°. However, this difference is largely an artifact of the vector-averaging method, because declinations are scattered in both northern and southern orientations. The median value of +58° is a more representative inclination. As was the case with the subjacent Alburnett Formation valley-slope deposits, the fact that declinations of samples collected from sheared intervals retain an alignment associated with depositional stress implies that the measured remanence is primary.

Aurora Member. The lower till in the Aurora Member had not been sampled prior to this study. Three samples from this till had vector means of 16° declination and +65° inclination (Table 3, Figure 4). Two samples of the upper till within the Aurora Member had magnetic characteristics that are similar to those of the underlying, highly sheared, Winthrop Member. These include low NRM intensities and scattered declinations. Both inclinations, however, were +64°.

Cosmogenic-Isotope Dates

Samples from the intra-Alburnett paleosol give a burial age of 0.87 +/-0.43 Ma (Table 2). The large error limits are due to relatively low isotope concentrations within this profile. Nevertheless, the burial age here is consistent with correlation to both the Moberly Formation in Missouri (cosmogenic isotope date of 1.31 +/- 0.09 Ma) and the "B" till in eastern Iowa, which appears to be close in age to the 1.3 Ma date of the underlying tephra (Figure 1). The low isotope concentrations are due to the soil's weak development (an A/C profile) and indicate that this profile developed over <10 ka (Balco and Rovey, 2010). Thus, the ice advances that deposited the two Alburnett Formation tills (and by correlation the two Moberly and the "B"-"A4" tills reflect short-term fluctuations within the same major glaciation, not successive glacial episodes.

Isotope ratios within the upper Alburnett paleosol (the Westburg Geosol) give a burial age of 0.72 +/- 0.37 Ma, which provides a date for the overlying Winthrop Member. The large error limits again reflect relatively low isotope concentrations within a truncated Bt horizon, but the age is very consistent with Missouri dates for the correlative Fulton member (0.80 +/- 0.04 Ma, Table 2).

DISCUSSION

Glacial tills of the Alburnett Formation have a reversed magnetic remanence whereas those of the Wolf Creek Formation have normal remanence, as previously determined by Baker and Stewart (1984) and Baker (1985). The most surprising and intriguing new results are that the alluvial valley-fill and colluvial slope deposits in the upper part of the Alburnett Formation have normal depositional magnetic remanence. This transition from reversed to normal polarity occurred within a short interval of time between deposition of the upper till of the Alburnett Formation and deposition of the valley-fill and slope deposits within the same formation, confirming that the Alburnett and its equivalents were deposited shortly before a magnetic reversal.

The dates that are now available for the Alburnett tills and their lateral equivalents are inconsistent with the hypothesis that the reversal within the Alburnett Formation is the M/B transition. Which reversal might it be? The short Cobb Mountain "event," (now a normal-polarity subchron within the Matuyama Reversed Chron (Channell et al., 2002; Horng et al., 2002; Gibbard et al., 2005) is variously dated at intervals ranging from 1.17-1.19 Ma to 1.22-1.24 Ma. These dates are just slightly younger than the ~1.3 Ma date for the Alburnett Formation, based on its correlation to the Moberly and "B" tills (Fig.1, Table 2), and the latter range is within 1-σ error limits of the Missouri dates. Alternatively, if the valley-fill sediments within the Alburnett Formation at Conklin Quarry are somewhat younger than the subjacent till facies, this reversal conceivably might be as young as the Jarimillo Normal Polarity Subchron at 0.99-1.07 Ma (Cande and Kent, 1995).

SUMMARY AND CONCLUSIONS

1. This work confirms the general results of Baker and Stewart (1984) and Baker (1985). Tills of the Alburnett Formation are reversely magnetized, whereas younger tills of the Wolf Creek Formation have normal remanent polarity.

2. Based on cosmogenic isotope dates at Conklin Quarry and regional correlation to dated sections in eastern Iowa and northern Missouri, the normal-polarity tills are younger than the M/B boundary at 0.78 Ma, whereas the reversed polarity tills are older. Thus, the boundary between the Early and Middle Pleistocene is present within the pre-Illinoian till sequence throughout eastern Iowa.

3. Cosmogenic isotope dates for tills at Conklin Quarry support correlation of the two Alburnett Formation tills with the "B"-"A4" till sequence in eastern Iowa and with the two Moberly Formation tills in northern Missouri. Likewise, dates for the Winthrop Member at Conklin support correlation of that unit to the Fulton member in northern Missouri.

4. Locally preserved valley-fill and slope sediments, inset into the reversely magnetized Alburnett Formation tills, and capped by the Westburg Geosol at Conklin Quarry, have a normal detrital remanent magnetization. Therefore, a magnetic reversal (reverse to normal) is present within the Alburnett Formation. However, based on cosmogenic isotope dates and correlation to other dated sections, this reversal is too old to be the M/B transition. Instead, the normal remanence within the upper Alburnett alluvial/colluvial facies probably indicates deposition during either the Cobb Mountain or the Jarimillo Normal Polarity Subchron.

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