Revision to Nomenclature of the Zarah Subgroup of the Kansas City Group (Pennsylvanian) in Kansas

Stephan C. Oborny, Jon J. Smith, Anthony L. Layzell, Greg Ludvigson, and Franek Hasiuk
Kansas Geological Survey, University of Kansas, Lawrence, KS 66047-3724, USA

ABSTRACT

This paper provides a summary review of proposed nomenclatural revisions to the Zarah Subgroup of the Kansas City Group (Pennsylvanian) in Kansas and outlines changes adopted by the Kansas Geological Survey. The Iola Limestone, which comprises in ascending order the Paola Limestone, Muncie Creek Shale, and Raytown Limestone Members, is now considered the basal formation of the Zarah Subgroup. We reinstate the overlying Liberty Memorial Shale as originally defined by Clair (1943) in the area of Kansas City, Missouri. We also restrict the Wyandotte Limestone to include only, in ascending order, the Frisbie Limestone, Quindaro Shale, and Argentine Limestone Members. Furthermore, the Lane Shale is restricted in use and encompasses all strata within the shale-dominated interval between the top of the Argentine Limestone Member of the Wyandotte Limestone and the base of the overlying Plattsburg Limestone. Within the revised Lane Shale, the KGS now formally recognizes, in ascending order, the Lower Farley Limestone, Middle Farley Shale, and Upper Farley Limestone Members. The Bonner Springs Shale is now demoted in rank and included as the uppermost member within the Lane Shale.

INTRODUCTION

The Zarah Subgroup was first designated in Kansas by Moore (1948) to include the upper third of the Kansas City Group. Moore (1932, 1936) had previously formalized three formations within this interval: in ascending order, the Lane Shale, Wyandotte Limestone, and Bonner Springs Shale (fig. 1A). He also subdivided the Wyandotte Limestone into five members: in ascending order, the Frisbie Limestone, Quindaro Shale, Argentine Limestone, Island Creek Shale, and Farley Limestone (Moore, 1936). These lithostratigraphic units were later used by Zeller (1968) in The Stratigraphic Succession in Kansas, the current accepted stratigraphic guide and chart for the state (fig. 1B). Since the publication of Zeller (1968), additional published works, most notably Kansas Geological Survey Bulletin 246 (Heckel and Watney, 2002), demonstrated that the Zarah Subgroup interval has complex stratigraphic architecture necessitating the revision of numerous lithostratigraphic units within it. The stratigraphic revisions presented in Heckel and Watney (2002) were based in part on the work of Arvidson (1990) and Heckel (1992) and subsequently supported by additional research in McKirahan et al. (2003), Oborny (2015), and Oborny et al. (2017) and are summarized in the relevant sections of this paper. These stratigraphic revisions of the Zarah Subgroup have been adopted either in their entirety or near entirety by the Missouri and Iowa geological surveys and the Nebraska Conservation and Survey Division (Gentile and Thompson, 2004; Pope, 2012; Bridges et al., 2019; Bridges and Mulvany, 2019; R. M. Joeckel, personal communication,

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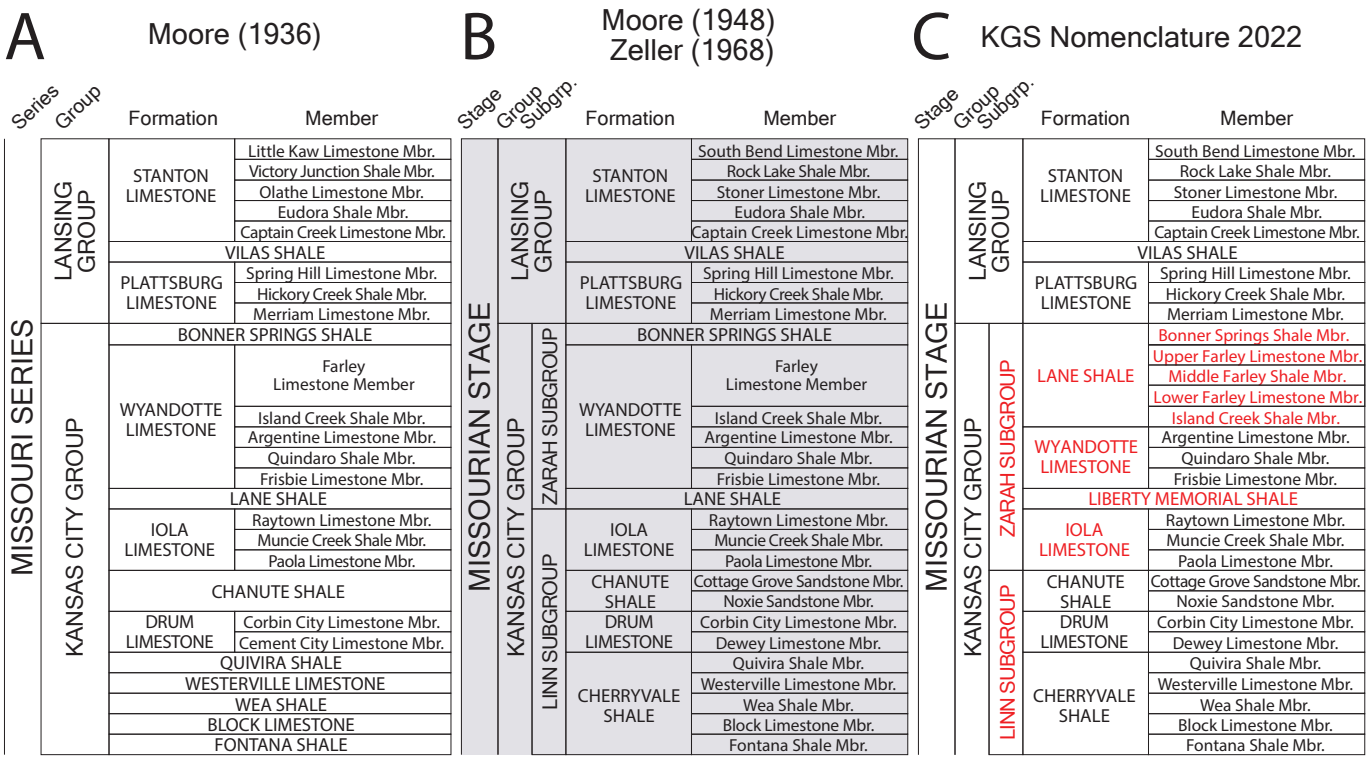

Figure 1. Nomenclature of (A) the Kansas City Group (Pennsylvanian) from Moore (1936), (B) the Linn and Zarah Subgroups of Moore (1948) as adopted by Zeller (1968), and (C) the newly adopted changes by the Kansas Geological Survey to the Zarah Subgroup (in red) based on the work of Heckel and Watney (2002) and Oborny et al. (2017).

November 2021). This paper reports changes to Zeller (1968) for the Zarah Subgroup and represents the formal adoption of these changes by the Kansas Geological Survey (KGS), bringing Kansas stratigraphic nomenclature for this subgroup into alignment with nomenclature in Missouri and into general agreement with Iowa and Nebraska.

HISTORY OF THE ZARAH SUBGROUP

Moore (1948) divided the Kansas City Group, in ascending order, into the Bronson, Linn, and Zarah Subgroups based on their dominant lithologies and on the persistent shale marker beds that bound them. Moore (1948) defined the Linn Subgroup as a shale-dominated unit that is lithologically distinct from the carbonate-dominated Bronson and Zarah Subgroups. Named after the former town of Zarah in Johnson County, Kansas, the Zarah Subgroup was predominantly characterized by the prominent limestone members of the Wyandotte Limestone, which were bounded below by the Lane Shale and above by the Bonner Springs Shale (fig. 2A). In the Kansas City area and elsewhere in Missouri, southwestern Iowa, and southeastern Nebraska, the Lane and Bonner Springs Shales were considered by Moore to be readily distinguishable as individual formations separated by the Wyandotte Limestone. The Wyandotte Limestone was described as thinning southwestward from the greater Kansas City Metropolitan area (e.g., Moore, 1932, 1936; Newell, 1935). Additionally, Moore (1948) concluded that the Lane and Bonner Springs Shales coalesced into a single unit, which he named the Lane-Bonner Springs Shale (fig. 2A, southwest side), that spanned the interval between the Iola and Plattsburg Limestones. The type section of the Lane Shale, near the town of Lane in southeastern Franklin County, Kansas, was correlated by Moore (1948, see fig. 4 therein) into Kansas City, Missouri, to a shale interval previously defined by Clair (1943) as the Liberty Memorial Shale. Given that the Lane Shale designation held seniority, Moore (1948) abandoned the junior synonym of Liberty Memorial in favor of Lane. The interpretation of a regionally thick Lane Shale was thus formulated and its basal contact with the Iola Limestone was also defined as the lower boundary for the Zarah Subgroup (fig. 1B).

Moore's stratigraphic concepts for the Zarah Subgroup were scrutinized decades later when Mitchell (1981), working in east-central and southeastern Kansas,

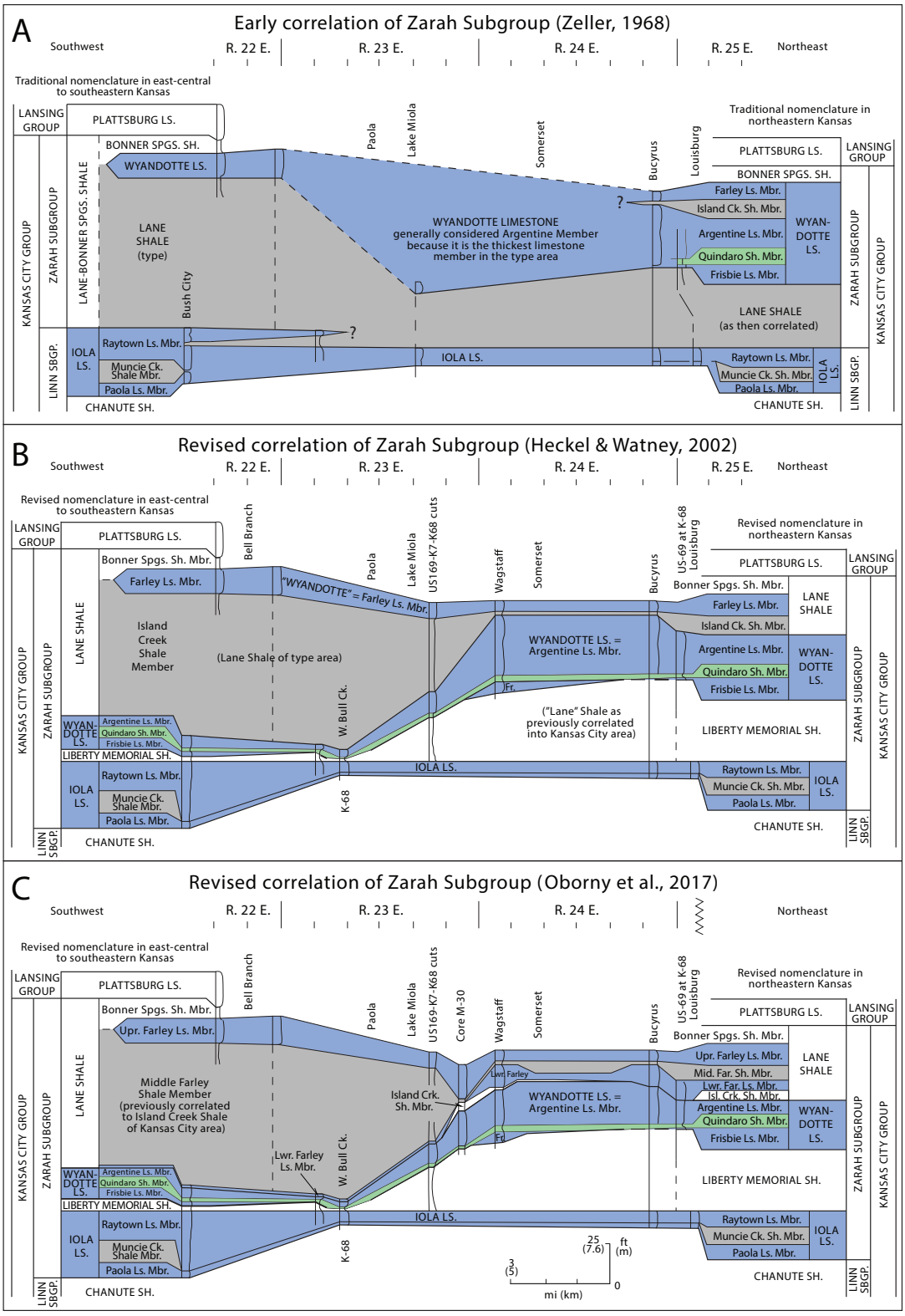

Figure 2. Previous and current correlations, nomenclatures, and classifications of upper Kansas City Group, Zarah Subgroup, strata between the Kansas City area (northeast) and east-central to southeastern Kansas. Panels A and B are slightly modified from Heckel and Watney (2002, p. 38). (A) Early correlations of Moore (1948) that were adopted for use by Zeller (1968). (B) Revised correlations as illustrated by Heckel and Watney (2002) highlighting combined findings of Arvidson (1990) and Heckel (1992). (C) Revised correlations reflecting findings published by Oborny et al. (2017). Blue and gray coloration denote limestone- and shale-dominated units, respectively; green highlights the Quindaro Shale Member. Ck. = Creek, Far. = Farley, Fr. = Frisbie, Isl. = Island, Ls. = Limestone, Lwr. = Lower, Mbr. = Member, Mid. = Middle, SBGP. = Subgroup, Sh.= Shale, SPGS = Springs, Upr. = Upper.

found evidence of miscorrelations. He described a thin fossiliferous shale bed, bounded by thin limestones, in the uppermost Raytown Limestone Member ("upper Raytown" of Miller, 1966) of the Iola Limestone. An abundant conodont assemblage from this shale, however, proved to be characteristic of the Quindaro Shale Member of the Wyandotte Limestone (fig. 2B). Considering these observations, it followed that the two bounding limestones were actually the much-condensed Frisbie and Argentine Limestone Members of the Wyandotte Limestone (Arvidson, 1990; Heckel, 1992; Heckel and Watney, 2002) rather than units of the Iola Limestone. It also followed that the Lane Shale overlying the Wyandotte Limestone in the same part of Kansas could not, contrary to Moore (1948), be correlative to the shale below the Wyandotte Limestone in the Kansas City area (Arvidson, 1990; Heckel, 1992; Heckel and Watney, 2002). Finally, a limestone in western Miami County, Kansas, that immediately overlies the Lane Shale in the Lane Shale type area and that was formerly classified as the Argentine or Argentine-Farley Member of the Wyandotte Limestone (e.g., Moore, 1932, 1936, 1948; Newell, 1935) must instead be the Farley Limestone *sensu stricto* (Arvidson, 1990; Heckel, 1992; Heckel and Watney, 2002). These observations proved to be the key for recognizing the previous miscorrelations and were the foundation for revisions to the Zarah Subgroup proposed by Heckel and Watney (2002).

ZARAH SUBGROUP (REVISED)

Heckel and Watney (2002) proposed revising the Zarah Subgroup to include the following formations in ascending order: the Iola Limestone, the Liberty Memorial Shale (reinstated herein), the Wyandotte Limestone (revised herein), and the Lane Shale (revised herein). This revision was suggested to correct long-standing miscorrelation between the Lane Shale in east-central Kansas and exposures of the Zarah Subgroup in northeastern Kansas as detailed below (fig. 2B). The geologic community has accepted and used this stratigraphic configuration of the Zarah Subgroup from both before and after publication of Heckel and Watney (2002), and it appears in numerous peer-reviewed publications up to the present (e.g., Samankassou and West, 2002; McKirahan et al., 2003; Gentile and Thompson, 2004; Heckel, 2013; Oborny, 2015; Oborny et al., 2017). The Zarah Subgroup type section, along with principal reference sections for most of its constituent units, is located along the southbound I-435 ramps to and from Holliday Drive in NE NW sec. 6, T. 12 S., R. 24 E. (latitude 39.039767, longitude -94.790914), approximately 3.5 miles northeast of the site of Zarah in Johnson County, Kansas (Heckel, 1992; Heckel and Watney, 2002).

Iola Limestone (revised)

Heckel and Watney (2002) proposed revising the lower boundary of the Zarah Subgroup to the base of the Iola Limestone because in east-central and southeastern Kansas where the intervening Liberty Memorial Shale pinches out (fig. 2B), the overlying Wyandotte Limestone rests directly on the Raytown Limestone Member of the Iola Limestone such that the two formations cannot be readily differentiated; hence, adjusting the subgroup boundary simplifies regional stratigraphic correlation (figs. 1C and 2B). Heckel and Watney (2002) also stated that moving the Iola Limestone to the base of the Zarah Subgroup serves to further emphasize the Linn Subgroup as a shale-dominated unit as originally conceived by Moore (1948). In accordance with the Stratigraphic Code (NACSN, 2021; Article 19—Revision and Article 24 part d— Mappability and thickness), the KGS accepts the proposed revision of the lower boundary for the Zarah Subgroup (fig. 1C).

Liberty Memorial Shale (reinstated)

The name Liberty Memorial Shale was established by Clair (1943) for shale between the Raytown Limestone and Frisbie Limestone Members in the Kansas City area. This name was abandoned by Moore (1948) after he correlated the previously named Lane Shale in Franklin County, Kansas, to the Liberty Memorial Shale exposed in Kansas City, Missouri (fig. 1B). Detailed outcrop and biostratigraphic analyses by Mitchell (1981), Arvidson (1990), and Heckel (1992) in Johnson, Franklin, and Miami counties, Kansas, established that in areas south and southwest of Kansas City, the type Lane Shale actually lies *between* the Argentine and Farley Limestones and cannot be correlative to the previously named Liberty Memorial Shale to the east-northeast of the type area of the Lane Shale (fig. 2B). For this reason, Heckel and Watney (2002) proposed reinstating the Liberty Memorial Shale of Clair (1943) to exactly the same strata to which it was originally applied by Clair (1943), namely the shale between the Iola and Wyandotte Limestones. In accordance with the North American Stratigraphic Code (NACSN, 2021; Article 19—Revision and Article 20 part e—Reinstatement), the KGS accepts the proposed reinstatement and revision of the Liberty Memorial Shale (fig. 1C).

Wyandotte Limestone (revised)

Heckel and Watney (2002) proposed restricting the Wyandotte Limestone to include, in ascending order, the Frisbie Limestone, Quindaro Shale, and Argentine Limestone Members. The Island Creek Shale and Farley Limestone Members (formerly at the top of the Wyandotte) are included, with the Bonner Springs Shale (reduced in rank and reclassified), as members of the redefined Lane Shale due to the Lane Shale overlying the Argentine Limestone regionally. In accordance with the North American Stratigraphic Code (NACSN, 2021; Article 19—Revision), the KGS accepts the proposed restriction of the Wyandotte Limestone to comprise the Frisbie Limestone, Quindaro Shale, and Argentine Limestone Members (fig. 1C).

Lane Shale (reclassified and revised)

Heckel and Watney (2002) proposed placing the revised Lane Shale above the Wyandotte Limestone based on the correlation work of Arvidson (1990) and Heckel (1992), recognizing the Argentine Limestone Member at the base of the Lane Shale in areas south and southwest of Kansas City and the miscorrelation of the Lane Shale by Moore (1948) to the now reinstated Liberty Memorial Shale. Heckel and Watney (2002) reclassified and revised the Lane Shale to include, in ascending order, the Island Creek Shale Member, the Farley Limestone Member—comprising three informal units (lower limestone, middle shale, and upper limestone)—and the Bonner Springs Shale, which was demoted in rank to member due to its sometimes undifferentiable nature from what was then identified as the underlying Island Creek Shale southwest of the Kansas City area. Thus, the Lane Shale regionally includes all units overlying the Argentine Limestone and underlying the Plattsburg Limestone (fig. 2B). Heckel and Watney (2002) established a neostratotype for the Lane Shale near the town of Osawatomie in southwestern Miami County along the west line of sec. 28, T. 18 S., R. 22 E. (latitude 38.454944, longitude -94.992238) that represented a more complete exposure of the interval.

Heckel and Watney (2002) proposed that the Island Creek Shale Member correlated with, and comprised the bulk of, the Lane Shale in its type area in Franklin County based primarily on outcrop exposures (Ardvison, 1990; Heckel, 1992; Watney and Heckel, 1994; McKirahan et al., 2003; fig. 2B). Although largely in agreement with the proposed revisions to the Zarah Subgroup in previous studies, Oborny et al. (2017) reported that the Island Creek Shale Member and informal lower Farley limestone could be readily traced through closely spaced subsurface geophysical logs (fig. 3) to an uppermost thin

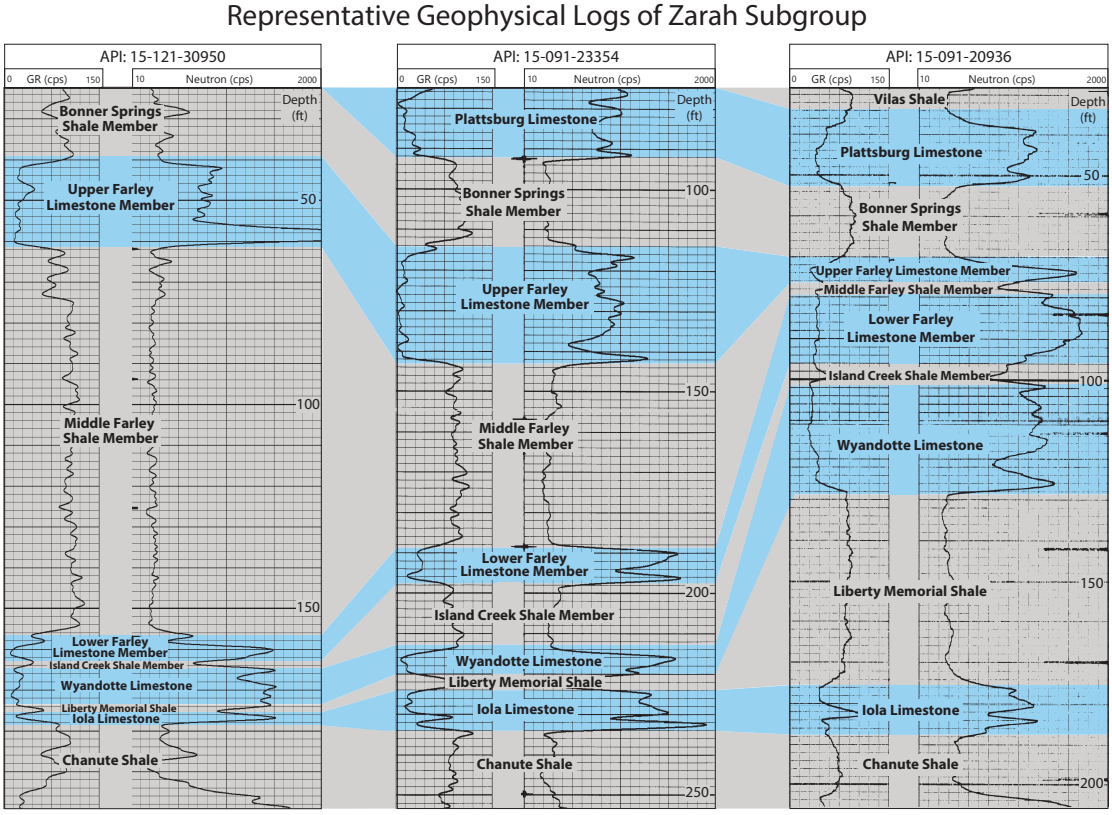

Figure 3. Representative subsurface geophysical well logs for the newly revised Zarah Subgroup from north-central Johnson County to southwestern Miami County, Kansas. Figure 4 shows the location of logs. These logs were used in subsurface correlations by Oborny and Hasiuk (2022). Blue and gray colorations denote limestone- and shale-dominated units, respectively. Drill depths on logs are in feet below surface. Datum is set at the base of the Iola Limestone.

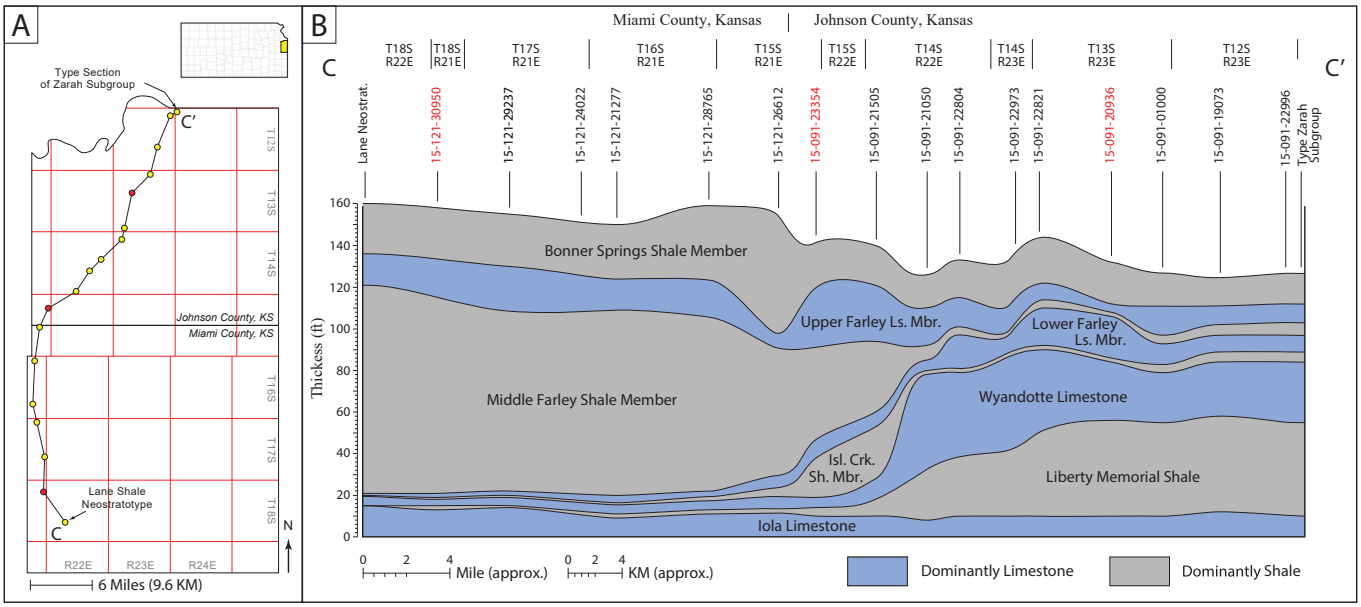

Figure 4. Cross section showing subsurface geophysical correlations between the Lane Shale neostratotype and Zarah Subgroup type sections established by Heckel (1992) and Heckel and Watney (2002). (A) Path and location of logged wells used to construct cross section C–C' traversing Miami and Johnson counties in Kansas. Inset map shows location of the two counties in east-central Kansas. (B) Cross section C–C' showing stratigraphic interpretation of the Zarah Subgroup derived from subsurface geophysical data. API numbers for all wells are shown. Wells 15-121-30950, 15-091-23354, and 15-091-20936 (shown in red print) were used in constructing fig. 3. Geophysical data used by Oborny and Hasiuk (2022) are available at the KGS (Kansas Geological Survey, 2021). Datum is set at the base of the Iola Limestone.

shale and limestone at the top of the Argentine Limestone at the Lane Shale neostratotype as designated by Heckel and Watney (2002) in southwestern Miami County. In addition, the thick shale at the Lane Shale neostratotype, correlated by Heckel and Watney (2002) to the Island Creek Shale Member, could be correlated northward to the then-informal middle shale division of the Farley Limestone Member at the type locality of the Zarah Subgroup (figs. 2C and 4). Oborny et al. (2017) proposed formalizing the Lower Farley Limestone, Middle Farley Shale, and Upper Farley Limestone as members of the Lane Shale given that (1) the Farley subdivisions are well established in the regional literature (e.g., Newell, 1935; Crowley, 1969; Heckel and Watney, 2002; McKirahan et al., 2003; Gentile and Thompson, 2004) and (2) they are economically exploited for building stone and crushed aggregate (NACSN, 2021; Article 22 part g—Economically exploited units).

In accordance with the North American Stratigraphic Code (NACSN, 2021; Article 19—Revision), the KGS accepts the proposed revisions to the Lane Shale: (1) comprising, in ascending order, the Island Creek Shale, Lower Farley Limestone, Middle Farley Shale, Upper Farley Limestone, and Bonner Springs Shale Members, (2) formalizing the lower, middle, and upper divisions of the Farley, and (3) changing the rank of the Bonner Springs Shale to member within the Lane Shale (fig. 1C).

SUMMARY OF FORMALLY ADOPTED ZARAH SUBGROUP NOMENCLATURAL REVISIONS

The following changes are adopted by the Kansas Geological Survey, and the stratigraphic chart of Zeller ([1968] 2018) is modified accordingly (fig. 1C).

1. The Iola Limestone formation is recognized as the basal formation of the Zarah Subgroup as proposed by Watney and Heckel (2002), based on its close stratigraphic association with overlying carbonate-dominated strata and by the often indiscrete contact between it and the overlying Wyandotte Limestone in east-central and southeastern Kansas, where the intervening Liberty Memorial Shale is absent.
2. The Liberty Memorial Shale, as defined and described by Clair (1943) in Kansas City, Missouri, is reinstated as proposed by Heckel and Watney (2002), and it now appears on the updated stratigraphic chart of Zeller ([1968] 2018).
3. The Wyandotte Limestone is now restricted to include only, in ascending order, the Frisbie Limestone, Quindaro Shale, and Argentine Limestone Members as proposed by Heckel and Watney (2002).

4. The lower boundary position of the Lane Shale, as proposed by Heckel and Watney (2002), is now placed at the top of the Argentine Limestone Member of the revised Wyandotte Limestone. Furthermore, the KGS now formally recognizes the Lane Shale to comprise the Lower Farley Limestone, Middle Farley Shale, and Upper Farley Limestone Members as proposed by Oborny et al. (2017).
5. The Bonner Springs Shale is now demoted to member and is included as the uppermost member of the Lane Shale as proposed by Heckel and Watney (2002).

KGS STRATIGRAPHIC NOMENCLATURE COMMITTEE

This paper was completed by current members of the Kansas Geological Survey's Stratigraphic Nomenclature Committee, which was re-established in July 2005 to address stratigraphic issues and establish accepted stratigraphic nomenclature for Kansas. The KGS Stratigraphic Nomenclature Committee is the official arbiter of stratigraphic nomenclature and issues in Kansas, subject to review by the State Geologist of Kansas. More information about the committee and Kansas stratigraphic nomenclature is available at the KGS website.

The KGS recognizes Zeller ([1968] 2018) as the current accepted stratigraphic guide and chart for Kansas. Nomenclatural changes will follow the North American Stratigraphic Code (NACSN, 2021), and changes will conform to international stratigraphic nomenclature standards as they apply to Kansas.

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