

The Upper Cretaceous (Turonian) Carlile Shale of Eastern South Dakota and Adjacent Areas with Correlations to the Black Hills of South Dakota and Wyoming*

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Abstract

The Late Cretaceous Carlile Shale (Middle and Upper Turonian) and its equivalents range from the Rocky Mountains to the Black Hills and eastward into Kansas, Minnesota, Iowa and northeast Nebraska and give a glimpse of the extent of the eastern margins of the Carlile Seaway. In eastern South Dakota, the Carlile Shale is exposed in at least two granite quarries near Milbank in Grant County, along Firesteel Creek near Mitchell in Davison County and at several small exposures near Yankton. These exposures preserve a few ammonites along with an abundant and diverse shark fauna. Merewether and Cobban (1981, 1983), Kennedy, et al. (2001), and Merewether, et al. (2007) are some of the leading paleontologists and geologists to study and describe the Turonian cephalopod fauna and lithology from the eastern portion of the Western Interior Seaway.

Only a limited amount of ammonite material has been found along the eastern margin so it has been difficult to correlate much of the eastern portion of the seaway with that of the west. The only way to accurately date the limited exposures and isolated occurrences from the eastern margin of the seaway is to identify the ammonites and compare them with those found around the Black Hills. Because Carlile Shale exposures on the flanks of the Black Hills comprise a nearly complete succession of Turonian aged rocks within the Western Interior, they constitute the best opportunity for comparison and accurate dating. Herein we describe the ammonite fauna from exposures in the eastern South Dakota and adjacent areas and compare them with those from the Black Hills to determine the biostratigraphic ammonite zones and ages present in the eastern margin of the Carlile Seaway.

Selected References

Kennedy, W.J., W.A. Cobban, and N.H. Landman, 2001, A revision of the Turonian members of the ammonite Subfamily Collignoniceratinae from the United States Western Interior and Gulf Coast: Bulletin of the American Museum of Natural History, v. 267, 148 p.

Merewether, E.A., and W.A. Cobban, 1981, Mid-Cretaceous formations in eastern South Dakota and adjoining areas, stratigraphic, paleontologic, and structural interpretations, *in* R.F. Brenner, and others, eds., Cretaceous stratigraphy and sedimentation in northwest Iowa, northeast Nebraska, and southeast South Dakota: Iowa Geological Survey Guidebook Series No. 4, p. 43-56.

Merewether, E., W. Cobban, and J. Obradovich, 2007, Regional disconformities in Turonian and Coniacian (Upper Cretaceous) strata in Colorado, Wyoming, and adjoining states - Biochronological evidence: Rocky Mountain Geology, v. 42, p. 95-122.

The Upper Cretaceous (Turonian) Carlile Shale of Eastern South Dakota and adjacent areas with correlations to the Black Hills of South Dakota and Wyoming

**BY
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AND
NEAL L. LARSON**

Presenter's notes: This study concentrates on the biostratigraphic correlations of three contiguous ammonite biozones that can be identified on the Eastern Margin of the Western Interior Cretaceous Seaway with the same biozones located approximately 400 miles to the west.

TALL SHOULDERS TO STAND ON

George Shurr

Richard Hammond

Greg Ludvigson

Al Merewether

Bryan Witzke

Don Hattin

Dale Setterholm

Robert Sloan

Bill Cobban

Presenter's notes: Early field work was conducted by Meek and Hayden, 1860, and Hall and Meek, 1856. Contemporary investigators include those named above who work(ed) for the USGS, South Dakota, Minnesota, and Iowa Geological Surveys.



Presenter's notes: Granite, limestone, and vertebrate "hash" from the Dakota Rose Quarry that Bill showed me in 1987.



**“THERE ARE
AMMONITES
THERE,
YOU KNOW”**

Bill Cobban, 1987

Presenter's notes: Bill at the Dakota Rose Quarry in April 1993 along with Jake Hancock, Jim and Joyce Grier, and Dallas (Photo credit), Olga, and Steve Jorgensen.

A REVISION OF THE TURONIAN
MEMBERS OF THE AMMONITE
SUBFAMILY COLLIGNONICERATINAE
FROM THE UNITED STATES WESTERN
INTERIOR AND GULF COAST

W. JAMES KENNEDY
WILLIAM A. COBBAN
NEIL H. LANDMAN

BULLETIN
OF THE
AMERICAN MUSEUM OF NATURAL HISTORY
NUMBER 267
NEW YORK : 2001

SUBSTAGE	STANDARD ZONE	RANGE OF TAXON
UPPER TURONIAN	<i>Prionocyclus germari</i>	
	<i>Scaphites</i> (S.) <i>nigricollensis</i>	<i>Prionocyclus wyomingensis</i> <i>Prionocyclus germari</i> <i>Prionocyclus pluricostatus</i>
	<i>Scaphites</i> (S.) <i>whitfieldi</i>	
MIDDLE TURONIAN	<i>Scaphites</i> (S.) <i>ferronensis</i>	<i>Prionocyclus macombi</i> <i>Prionocyclus novimexicanus</i> <i>Reesidites minimus</i>
	<i>Scaphites</i> (S.) <i>warreni</i>	
	<i>Prionocyclus macombi</i>	
	<i>Prionocyclus hyatti</i>	
	<i>Collignonicerias praecox</i>	
	<i>Collignonicerias woollgari</i>	
	<i>Mammites nodosoides</i>	
LOWER TURONIAN	<i>Vascoceras birchbyi</i>	
	<i>Pseudaspidoceras flexuosum</i>	
	<i>Watinoceras devonense</i>	

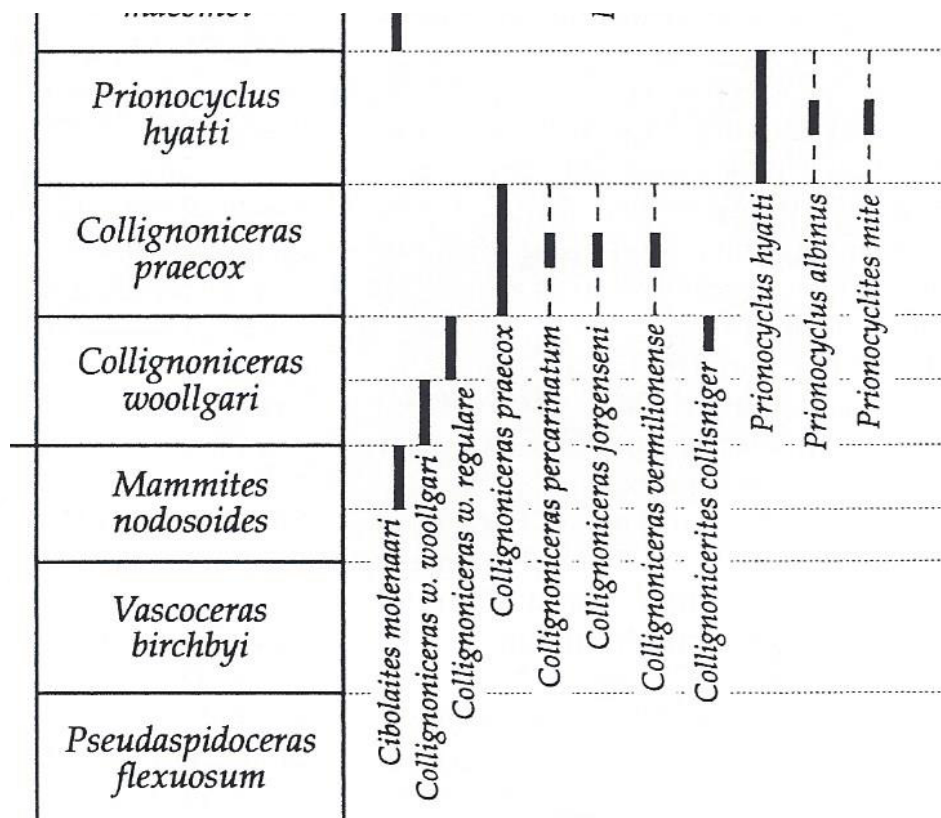
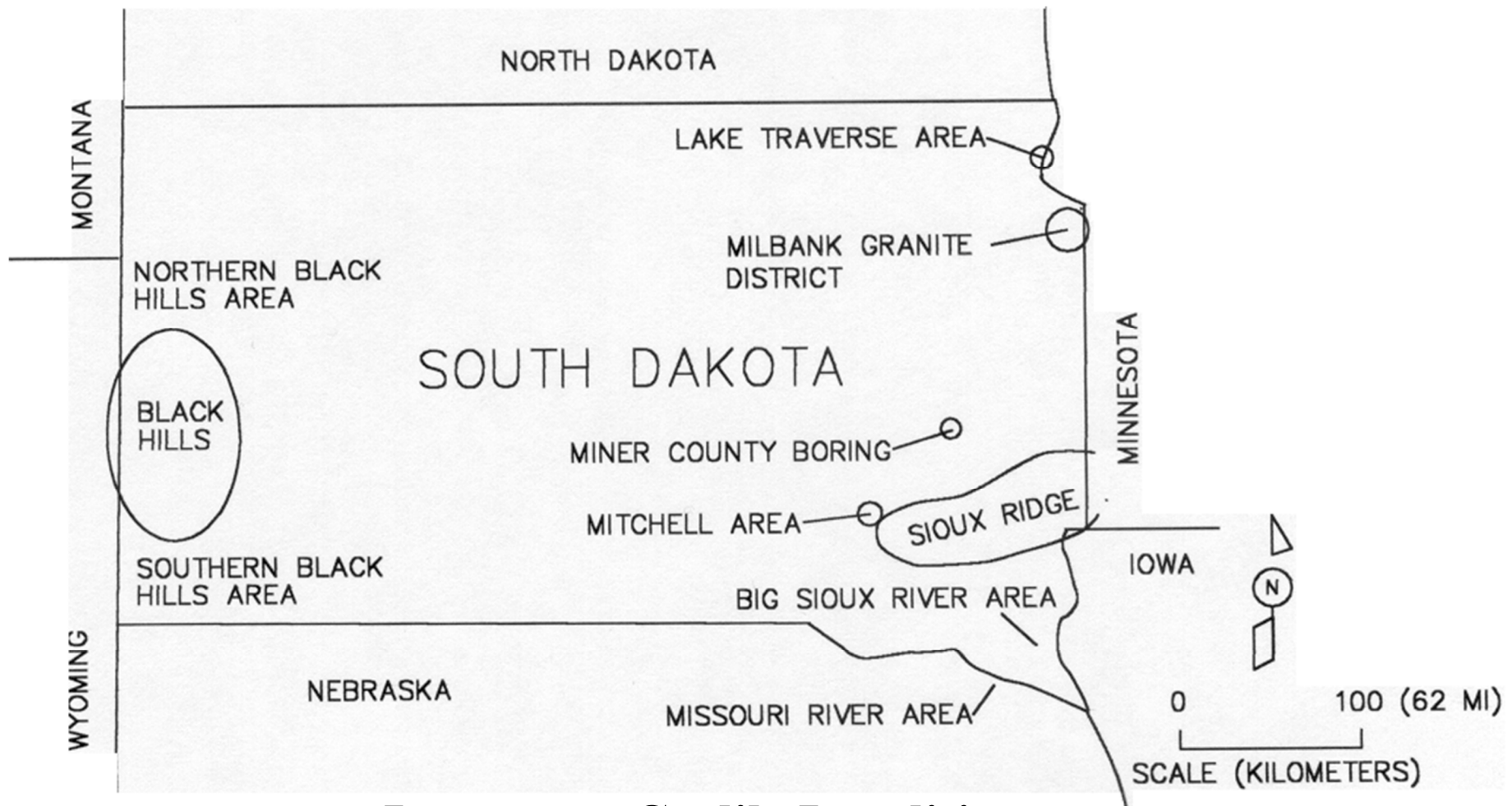


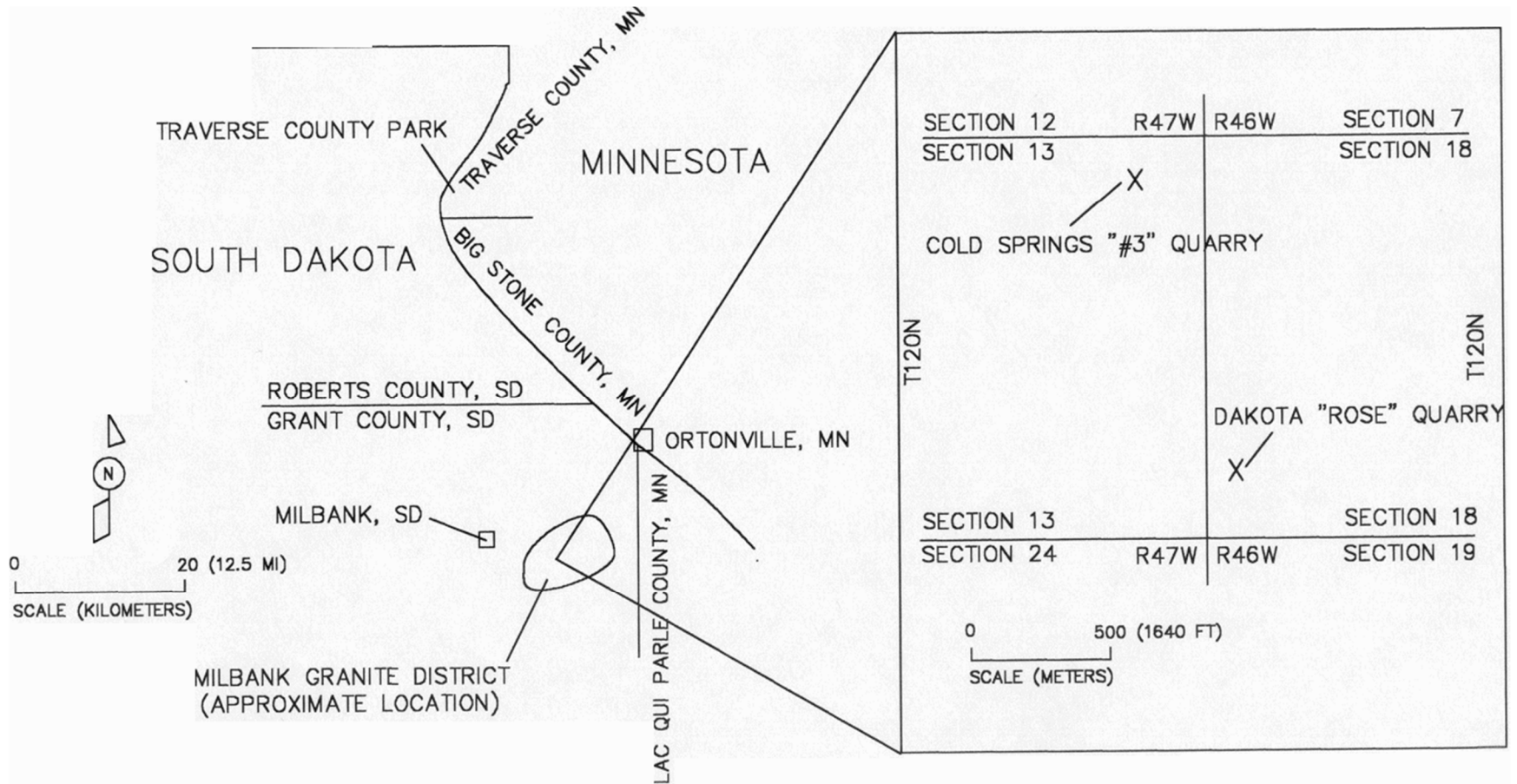
Fig. 3. Stratigraphic distribution of Collignoniceratinae in the U.S. Western Interior.

Presenter's notes: Three contiguous biozones, *C. woollgari*, *C. praecox*, and *P. hyatti*, can be correlated across the study area.



Important Carlile Localities In South Dakota

Presenter's notes: For brevity, only a few of these localities are discussed in this presentation.



Milbank Area, Grant Co., SD

Presenter's notes: Two quarries are described from SDJ's collecting trips between 1993 and 2005.



Dakota Rose Quarry, Grant Co, SD

Presenter's notes: My Mother, Olga Jorgensen (far left) and Jim Grier (right center). Carlile strata is present on the lower area in the bottom center of the photo. The glaciers presumably removed the strata from the upper weathering surface.



Presenter's notes: Monterey Bay appears to be a modern analog.



Joyce Grier in a Cretaceous Fish Market!

Presenter's notes: Intersection of two orthogonal fractures.



Xiphactinus audax
Dakota Rose Quarry, Grant Co, SD

Presenter's notes: At the 1996 RMS GSA (Rapid City) Stewart and Martin stated that this species should be present in this faunal suite – I had this specimen at that time.



Cretoxyrhina mantelli
Dakota Rose Quarry, Grant Co, SD

Presenter's notes: Amazing juxtaposition – shale with chert pebbles (left), granite “sliver” (middle), and vertebrate hash (right), all with a large shark tooth (*Cretoxyrhina mantelli*) – coooool!!



Ptychodus polygyrus
Dakota Rose Quarry, Grant Co, SD

Presenter's notes: Beautiful "pavement" teeth.



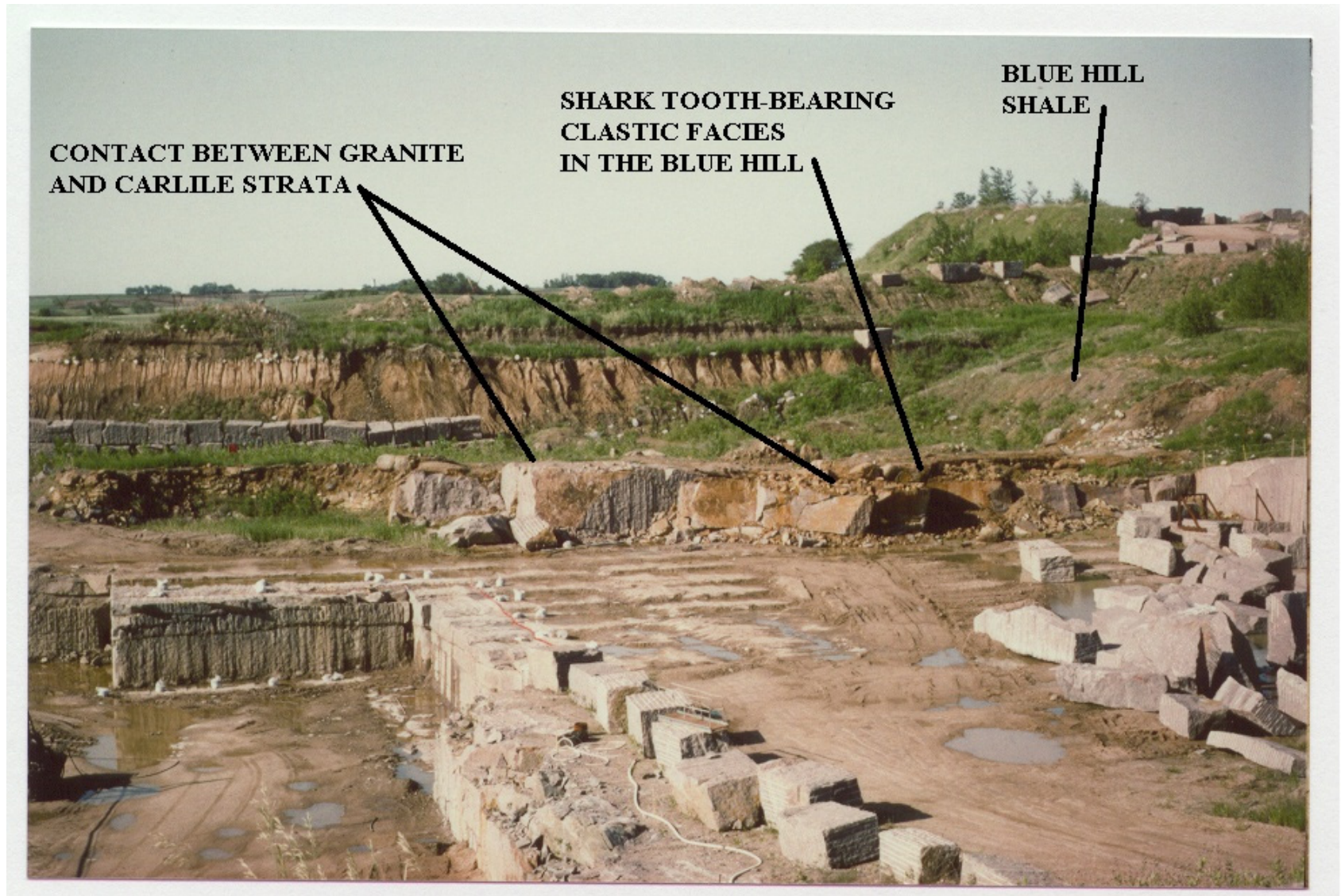
Actinocamax manitobensis
Dakota Rose Quarry, Grant Co, SD

Presenter's notes: Very rare belemnites that are water worn and show current orientation.



Collignoniceras woollgari regulare
Dakota Rose Quarry , Grant Co, SD

Presenter's notes: This Index Species identifies the biozone.



Cold Springs #3 (Hunter) Quarry, Grant Co., SD

Presenter's notes: Large blocks of granite for scale.



High School Group Collecting Shark Teeth at #3 Quarry



Two Hours Reward for a Sharp-Eyed Collector!



Ptychodus whipplei

Cold Springs #3 (Hunter) Quarry, Grant Co., SD

Presenter's notes: Very distinctive crown.



Prionocyclus hyatti

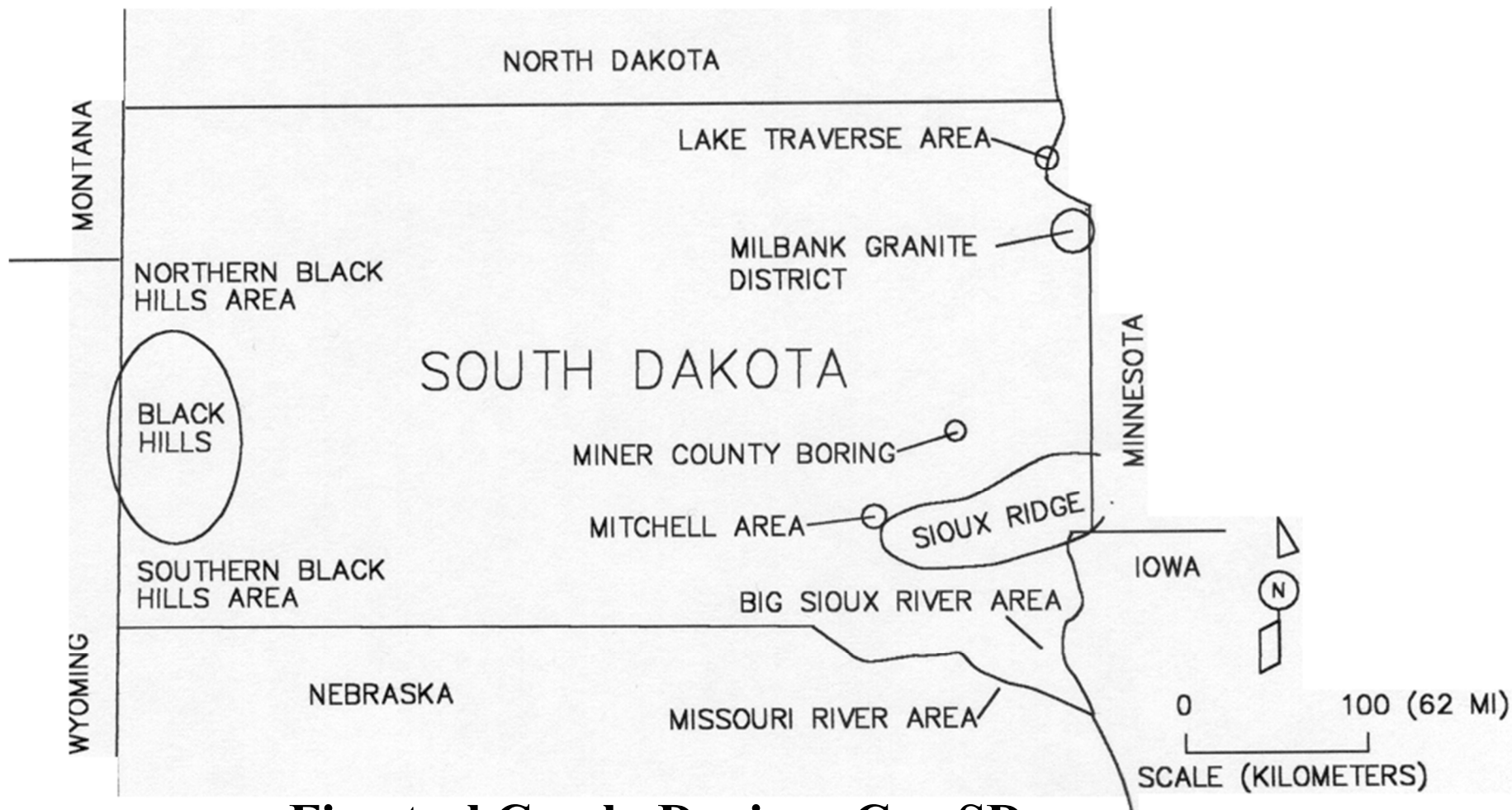
Rushmore Mall, Rapid City, Pennington Co., SD

Presenter's notes: This Index Species identifies the biozone. This species was collected from the Cold Springs quarry and was identified by Bill Cobban.



Scaphites carlilense Microconch and Macroconch
Osborne Co., KS

Presenter's notes: We can correlate not only to the west, but also to the south.



Firesteel Creek, Davison Co., SD
Mitchell, SD



Screening Gravel Bar on Firesteel Creek, Davison Co., SD

Presenter's notes: People have been collecting here since prehistoric times, including me collecting there beginning 50 years ago.



Carlile and Niobrara Outcrop on Firesteel Creek, Davison Co., SD

Presenter's notes: Base of the Niobrara forms the light-colored ledge above the Carlile shale. Dick Hammond (SD Survey), Gordon Bell (SDSM&T) measuring a section in 1997. Peter Harries, Greg Ludvigson, Brian Witzke and several others also visited in 1997.



Fossil-Rich Phosphate Pebble Sandstone Firesteel Creek, Davison Co., SD

Presenter's notes: This phosphate pebble sandstone is only six to eight inches thick. Note pronounced cross-bedding. Earl Manning and Mike and Pam Everhart identified 15 species of sharks, 5 species of rays, several species of fish and marine reptiles from this thin sandstone. One of the authors (SDJ) spent several years picking through the sand to recover specimens. One of the most unexpected species included tritor (jaw) fragments of the Chimaeroid (ratfish) *Ischyodus bifurcatus*! Earl described the depositional environment based on the recovered species



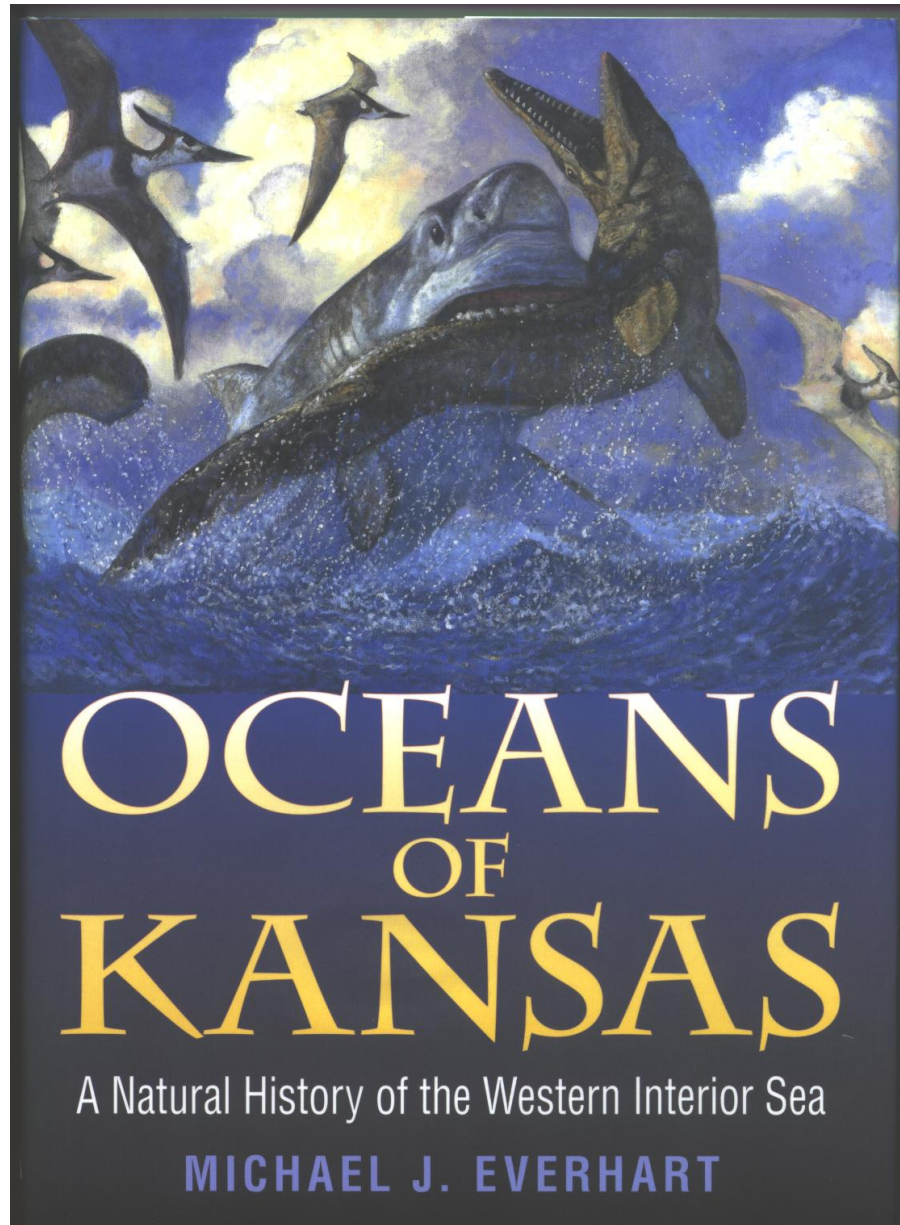
Shed Hadrosaurid Teeth

Firesteel Creek, Davison Co., SD

Presenter's notes: These shed teeth were recovered from the phosphate pebble sandstone shown on the previous slide. The two in the middle are definitely shed teeth. The other two are probably just phosphate pebbles.



Presenter's notes: The authors have both collected countless shed teeth of *Edmontosaurus annectens* from the Hell Creek Formation. The authors consider the two Turonian shed teeth shown on the previous slide to be “Eastern Margin” dinosaurs because no carcass could float across the Western Interior Seaway from Utah to eastern South Dakota because.....



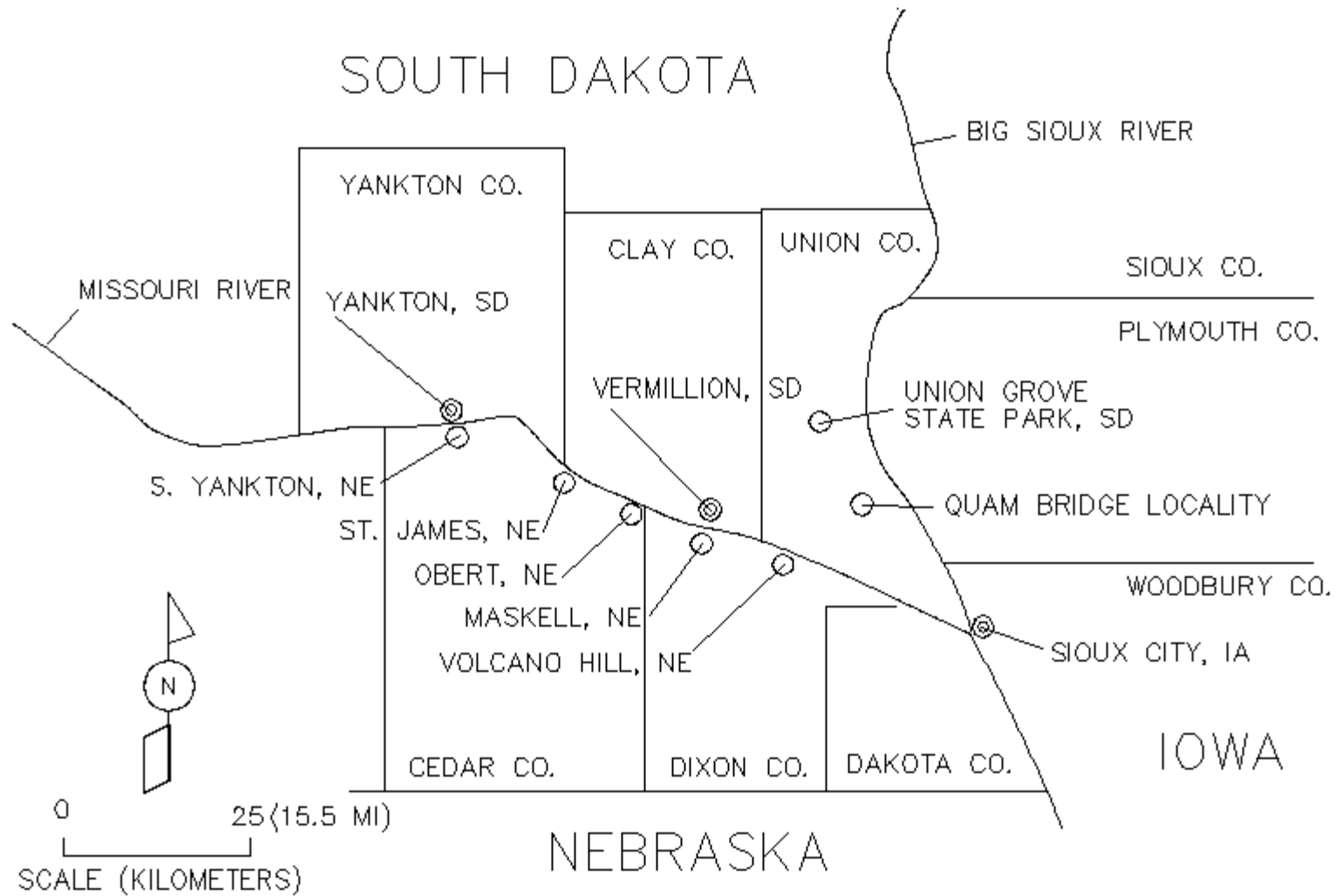
Presenter's notes: There were way to many hungry critters just waiting for a meal!



Presenter's notes: For instance, this *Cretodus crassidens* tooth is 56 mm by 40 mm – this shark could have been nearly 25 feet long!!!!!!!!!!



Presenter's notes: Approximately 20 foot-thick barrier bar showing a tidal inlet channel that migrated from south to north – right to left. This sandstone was deposited on the west end of the Precambrian Sioux Quartzite Ridge which was an emergent feature to the east of Mitchell, SD.



Southeast South Dakota and Northeast Nebraska Area

Presenter's notes: Now we will look at several localities near the Missouri River and Big Sioux River.



Historical Marker on Highway 12, Dixon Co., NE

Presenter's notes: Lewis and Clark thought the outcrop of Carlile had "lately been on fire". The heat was later attributed to the oxidation of large amounts of Marcasite (FeS_2 -x) present in the shale. One of the authors noted extremely abundant Selenite (CaSO_4) crystals on the outcrop, as well as the overpowering smell of Sulfur.



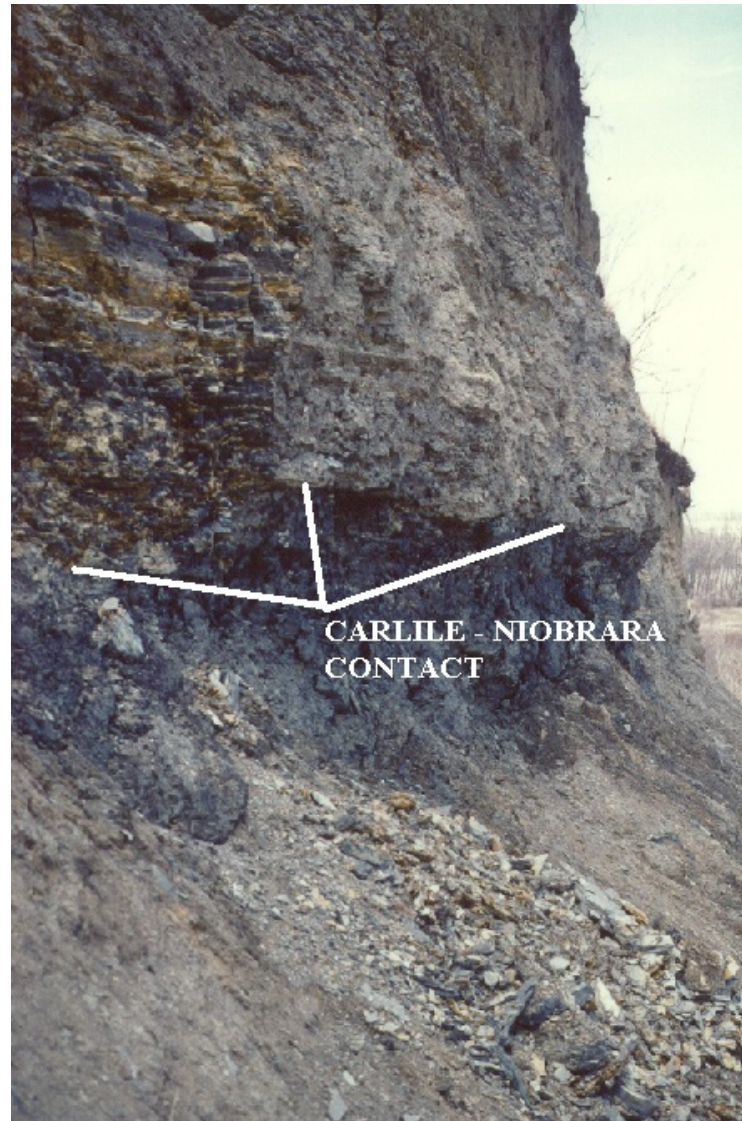
Ionia Volcano, Dixon Co., NE

Presenter's notes: Trees obscure the view of the Carlile Shale. Light tan Pleistocene age Peoria Loess constitutes the top 50 feet of the outcrop.



Collignoniceras woollgari regulare
Ionian Volcano, Dixon Co., NE

Presenter's notes: This Index Species identifies the biozone. Donated to the USGS.



Ionia Volcano, Dixon Co., NE

Presenter's notes: 2007 - Merewether, Cobban, Obradovich – lacuna (unconformity) spanning 5 million years in NE Nebraska.



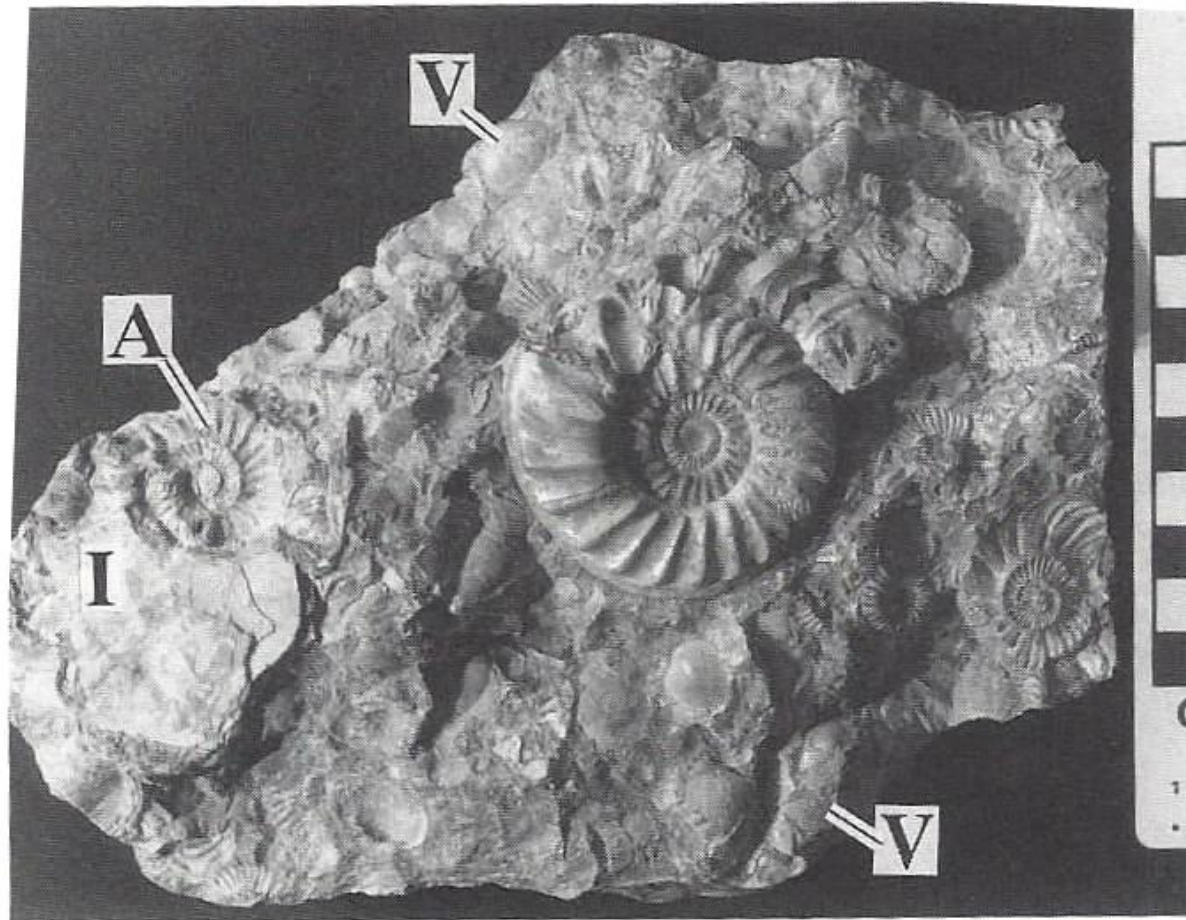
Huge Concretions in Blue Hill Member Union Grove State Park, Union Co., SD

Presenter's notes: Outcrop along Brule Creek. My son, Hans Jorgensen, for scale.



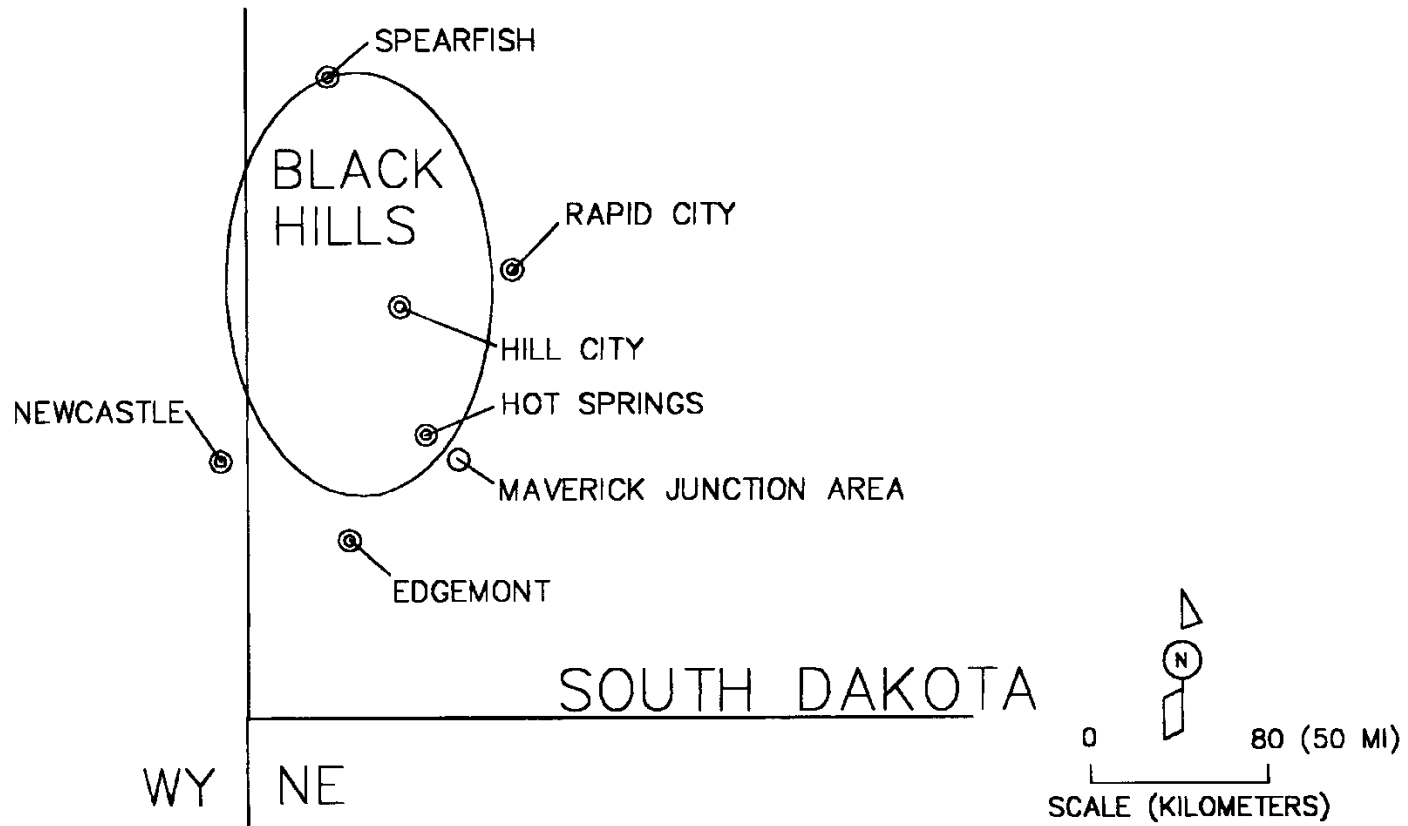
Very Large Log in Concretion in Blue Hill Member Union Grove State Park, Union Co., SD

Presenter's notes: Torredo clams confirm that this is a big log of wood that floated out to sea and then sank to the bottom before being enclosed in a concretion.



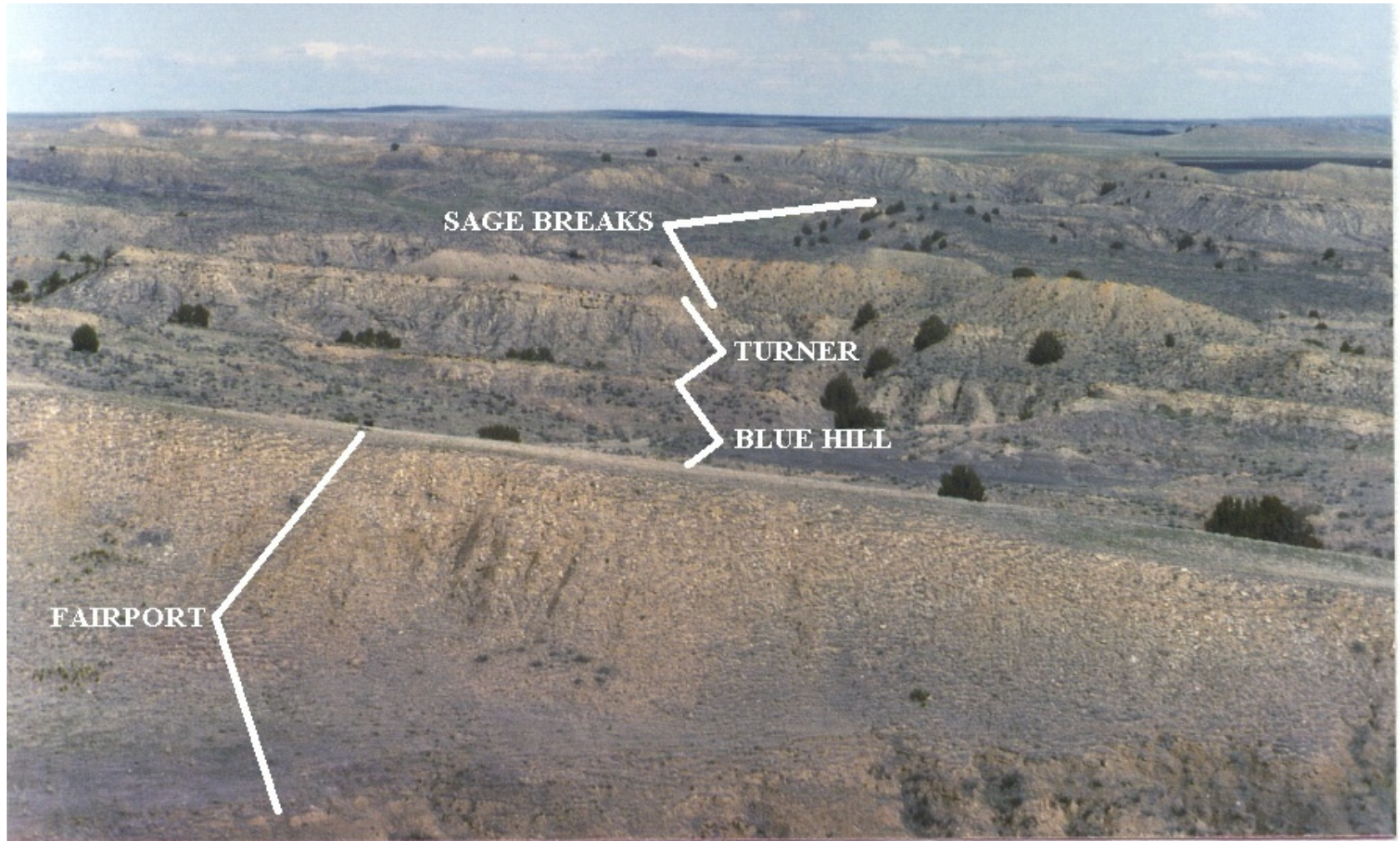
GSA Special Paper 287
Collignoniceras vermillionense with C. jorgenseni
Union Grove State Park, Union Co., SD

Presenter's notes: "Vermillion" was spelled with only one "l" when Meek and Hayden described *C. vermillionense* in 1860. This species is the large individual in the center of the photograph. The two smaller ammonite impressions were historically referred to as *Subprionocyclus percarinatus* until they were redescribed as *C. jorgenseni* in AMNH Bull. #267.



Black Hills Area, South Dakota and Wyoming

Presenter's notes: The following slide shows the Carlile outcrops east of Maverick Junction.



Complete Carlile Section at Maverick Junction Fall River Co., SD

Presenter's notes: The Greenhorn-Carlile contact is at the bottom of the view. The Carlile-Niobrara contact is near the top of the view. Now the correlations of the biozones across the study area will be shown.



Collignoniceras woollgari regulare
Maverick Junction, Fall River Co., SD

Presenter's notes: Note complete rostrum – typical anatomical feature of the genus Collignoniceras. Specimen is six cm across.



Collignoniceras woollgari regulare
Maverick Junction, Fall River Co., SD

Presenter's notes: Extreme intraspecific variation – Tatsuro Matsumoto (1965, Figure 6) illustrated a number of specimens from Newcastle, WY, and he stated that “there is a considerable extent of variation especially in the young stages” and called the variation “highly plastic” and referred to similar observations made by Haas (1946).



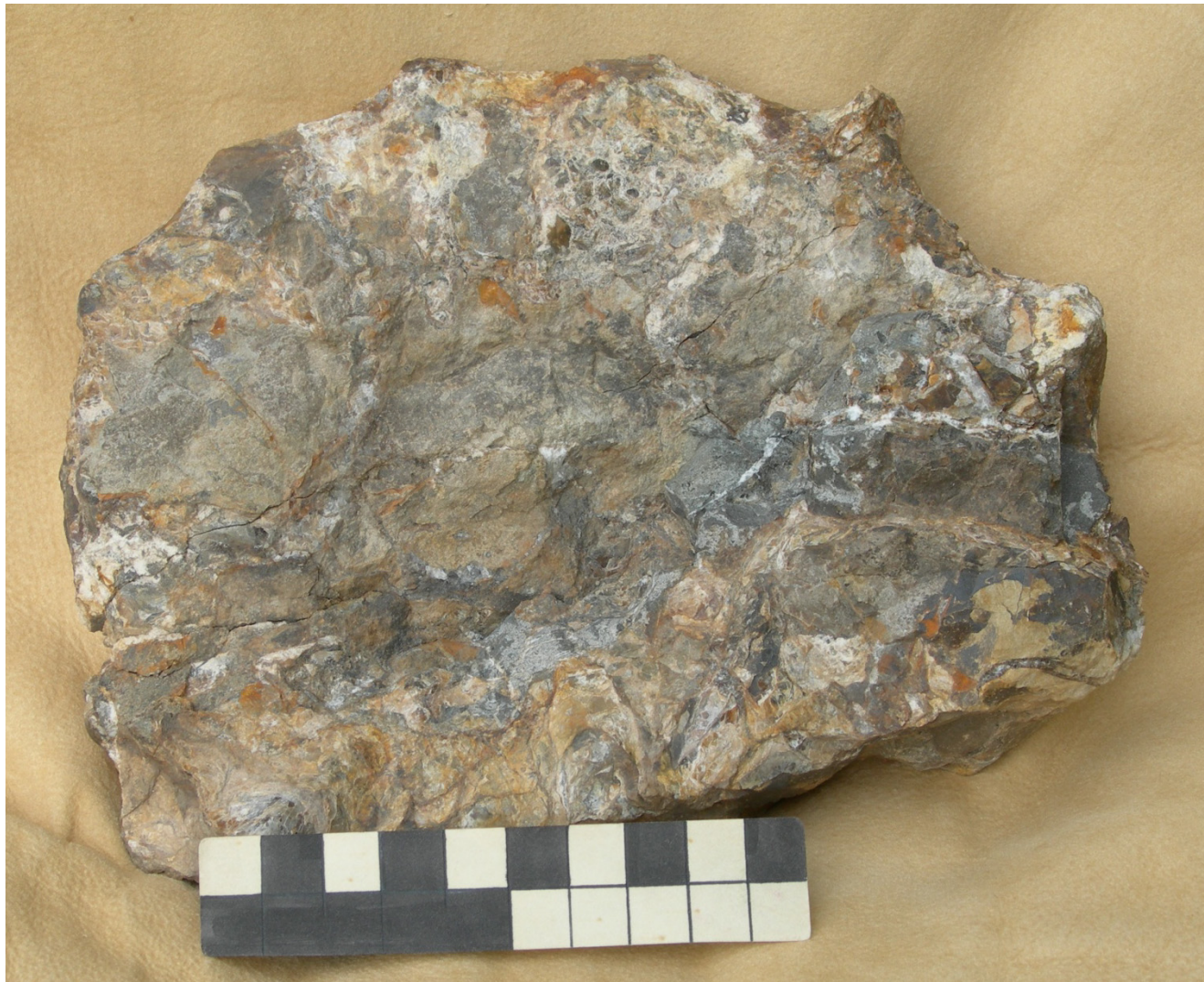
Collignoniceras woollgari regulare
Scaphites larvaeformis
Maverick Junction, Fall River Co., SD

Presenter's notes: Two pretty C. woollgari with Scaphites larvaeformis (1.5 cm long).



Collignoniceras praecox
Maverick Junction, Fall River Co., SD

Presenter's notes: Specimen is 13 cm across and is illustrated in AMNH Bulletin #267 – note visible sutures.



Collignoniceras praecox
Cedar Co., NE

Presenter's notes: Really beat up, but an important locality specimen



Collignoniceras vermillionense
Cedar Co., NE

Presenter's notes: Specimen is 7.5 cm across and is illustrated in AMNH Bull #267 – Note rostrum on left side.



Collignoniceras percarinatum
Cedar Co., NE

Presenter's notes: Previously illustrated as Subprionocyclus percarinatus by Cobban in USGS PP 1253 in 1983, starting with Ammonites percarinatus Hall and Meek, 1856. Renamed in AMNH Bull #267.



Collignoniceras jorgenseni
Cedar Co., NE

20 cm



Collignoniceras praecox (bottom right)

Collignoniceras jorgenseni

Maverick Junction, Fall River Co., SD

Presenter's notes: Donated to USGS and illustrated in AMNH Bull # 267. Babies and more mature (top two) *C. jorgenseni*. Largest fragment from this locality indicated an individual approximately nine cm across.



Placenticerias pseudoplacenta
Cedar Co., NE

Presenter's notes: Uncommon but has been found at many localities across the study area including Cedar Co., NE, Grant Co., SD, Davison Co., SD, Osborne Co., KS, and Fall River Co., SD. Formerly referred to as Proplacenticerias pseudoplacenta. Kennedy and Wright (1983) synonymized Proplacenticerias with Placenticerias.

SUMMARY:

Collignoniceras woollgari regulare zone –

Lower Middle Turonian Substage

Upper Fairport Member

- **Dakota Rose Quarry, Grant Co. SD**
- **Maverick Junction – Fall River Co., SD**
- **Ionia Volcano, Dixon Co., NE**

SUMMARY:

Collignoniceras praecox zone –

Lower Middle Turonian Substage

Lower Blue Hill

- **Yankton Area, Cedar Co. NE**
- **Union Grove State Park, Union Co., SD**
- **Maverick Junction – Fall River Co., SD**

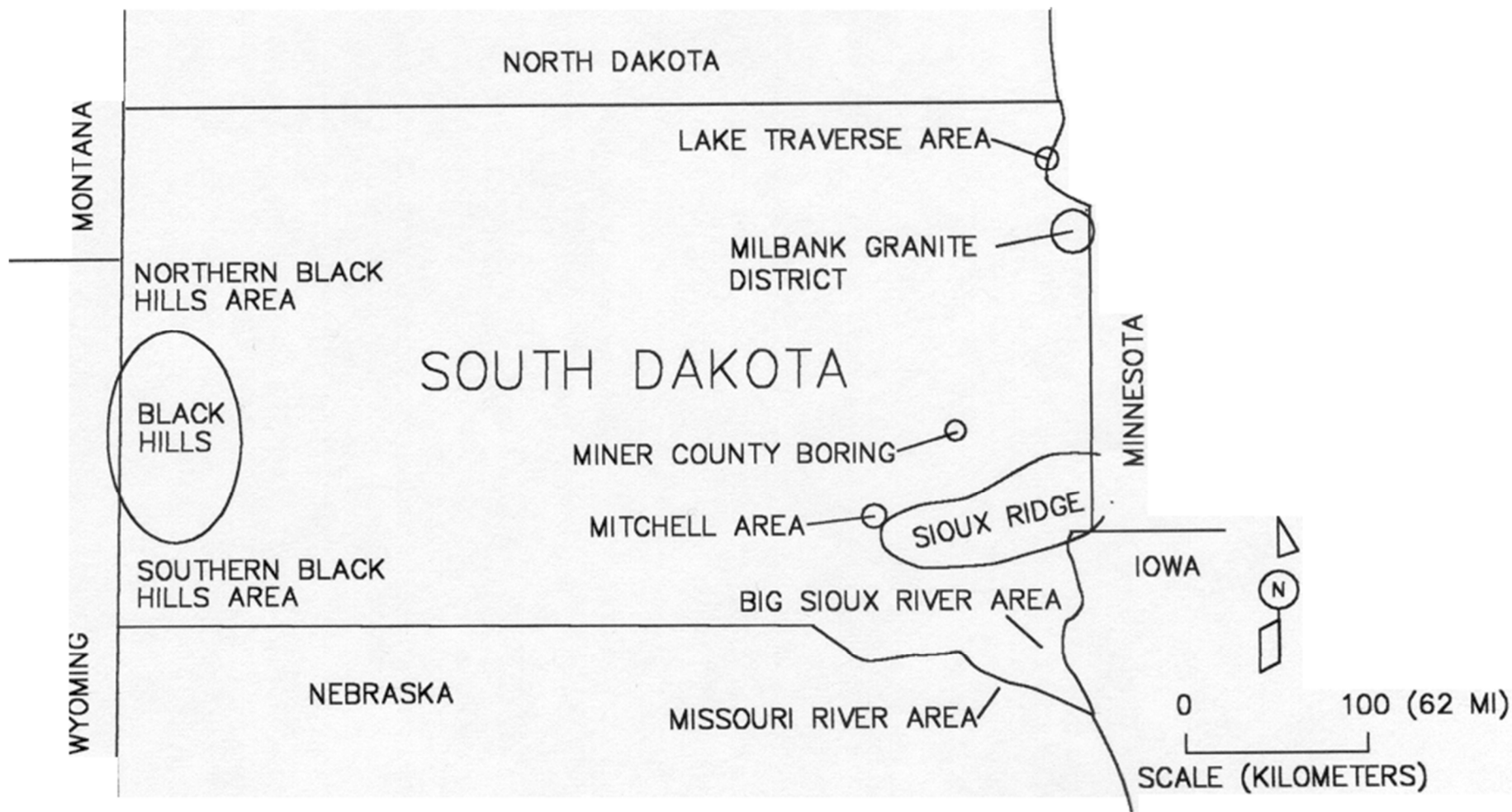
SUMMARY:

Prionocyclus hyatti zone –

Middle Middle Turonian Substage

Upper Blue Hill/Pool Creek Member

- Cold Springs Quarry, Grant Co. SD**
- Northern Black Hills, Butte Co., SD**
- Rapid City Area, Pennington Co., SD**



Important Carlile Localities In South Dakota

Presenter's notes: So what have we learned about the Eastern Margin of the Western Interior Seaway?



**“THERE ARE
AMMONITES
THERE,
YOU KNOW”**

Bill Cobban, 1987



Presenter's notes: Something to “cleanse your palate”....



Presenter's notes: Critters from the *Baculites scotti* zone of the Pierre Shale.