PALEOKARST IN THE KATAKTURUK DOLOMITE (PROTEROZOIC), NORTHEASTERN BROOKS RANGE, ALASKA

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ABSTRACT

The Katakturuk Dolomite (~2,500 m thick) crops out in the Sadlerochit, Shublik, and Kikiktat Mountains of the northeastern Brooks Range and represents predominantly shallow-water carbonate sedimentation on a Late Proterozoic (700-800-m.y.-old, minimum age), south-facing (present-day) passive margin ramp. The formation is subdivided into 16 informal units that approximate third-order depositional sequences. Paleokarst features recognized in 9 units resulted from episodic subaerial exposure of the Katakturuk carbonate ramp during sea-level lowstand. Paleoexposure surfaces are planar to scalloped and jagged (karren). Paleokarst alteration zones (cm- to m-scale) consist of solution pipes, vertical cracks, and subhorizontal cavities filled with collapse breccia, speleothemic flowstone, and cave popcorn.

The two uppermost units of the Katakturuk Dolomite contain large-scale (10's-of-m-thick) solution collapse breccias separated by unaltered host rock. This intense karstification event followed regional tectonic uplift of the carbonate ramp and preceded deposition of the overlying Nanook Limestone in Late Proterozoic or Early Cambrian time.

INTRODUCTION

The Katakturuk Dolomite (Dutro, 1970) is considered to be between 700 to 800 million years old (minimum age; Clough et al., 1990) and is exposed in the anticlinal cores of the Sadlerochit and Shublik Mountains (Fig.1) and also in the Kikiktat Mountain region. The Sadlerochit Mountains form the northernmost salient of the northeastern Brooks Range, an east-west trending arctic Alaska orogenic belt of Mesozoic to Cenozoic age.

The south-dipping Katakturuk Dolomite is composed of ~2,500 m of predominantly cyclical shallow-water carbonate including stromatolites, crossbedded oolitic grainstone, and peritidal-laminated mudstone that formed a south-facing (present-day) passive margin ramp (Clough, 1989). We have subdivided the Katakturuk succession into 16 units, A through P (Table 1), based on the informal mapping members of Robinson et al. (1989), which approximate third-order depositional sequences (Clough and Goldhammer, 1992). Ancient subaerial exposure features (paleokarst) preserved in the Katakturuk Dolomite record relative sea-level lowering and (or) tectonic uplift. Seven units, A, B, F, H, I, J, and K, are punctuated by small- to large-scale paleokarst features that mark hiatuses in Katakturuk Dolomite deposition. The upper two units, O and P, are intensely karstified and chronicle a regional uplift event that followed Katakturuk Dolomite deposition.

PALEOKARST FEATURES

Subaerial exposure of carbonate successions due to eustatic sea-level fall or tectonic uplift, when of sufficient extent and duration, results in nondeposition, erosion, and dissolution by meteoric waters (Esteban and Klappa, 1983). Ancient degraded carbonate landforms and features created by subaerial meteoric diagenesis preserved in the rock record are called paleokarst. We recognize three size scales of paleokarst in the Katakturuk Dolomite (following Choquette and James, 1988): (1) Depositional, (2) Local, and (3) Regional (described below and shown in Table 1).

(1) Depositional paleokarst is cm-scale or smaller and forms during the final stage of sediment accretion to sea level, as a manifestation of progradation/ aggradation in shallowing-upward cycles. Subaerial exposure duration is brief, and its effects are subtle, confined to surface dissolution and near-surface cementation. Depositional paleokarst in the Katakturuk Dolomite consists of planar disconformity surfaces typically in peritidal cryptalgal laminite at the tops of shallowing-upward cycles in six units (Table 1).

(2) Local paleokarst forms when the carbonate ramp shallow-subtidal environment is subaerially exposed due to eustatic sea-level fall or minor tectonic uplift. Local paleokarst development in the Katakturuk Dolomite (recognized in seven units; Table 1) was minor to laterally extensive, cm-scale or larger, and includes: karren-scalloped (Fig.2a) and jagged (Fig.2b) dissolution surfaces that locally truncate bedding; solution pits and pipes filled with collapse breccia (Fig.2c); vertical solution cracks and subhorizontal solution cavities filled with collapse breccia, speleothem flowstone (Fig.2d), and cave popcorn (Fig.2e).

(3) Regional-scale paleokarst occurs when an entire carbonate ramp is subaerially exposed for sufficient duration to allow deep and extensive dissolution, alteration, and subsequent erosion. The uppermost

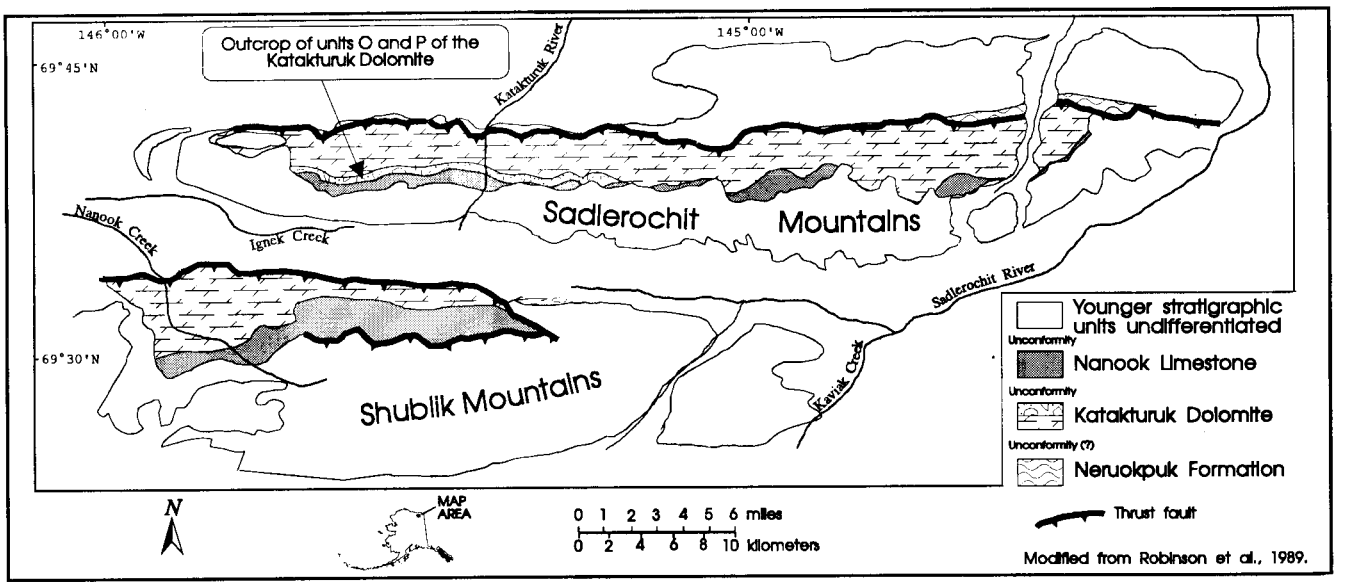

Fig.1. Distribution of Katakturuk Dolomite (mostly south-dipping outcrop) in Sadlerochit and Shublik Mountains, Alaska.

Table 1. Summary of Paleokarst in Katakturuk Dolomite Units

UNIT	PALEOKARST – SCALE[1] & FEATURE(S)[2]	INFORMAL MBR NAME[3]
P	[3] *lscb*	upper siliceous
O	[3] *lscb*	dolomite breccia
N		black-laminated dolomite
M		horsetooth dolomite
L		pink dolomite
K	[1] *pds*; [2] *spipe, cb, kar*	upper gray craggy
J	[1] *pds*; [2] *kar*	thin-bedded algal
I	[1] *pds*; [2] *spipe, cb, vscrk, spthm, kar*	lower gray craggy
H	[2] *spipe, cb, kar, vscrk,*	brown marker
G		white marker
F	[1] *pds*; [2] *cb, kar*	silicified oolite
E		thin laminated
D		cobweb
C		variegated
B	[1] *pds*; [2] *cb, kar*	zebra
A	[1] *pds*; [2] *cb, kar*	spire

[1]SCALE [1]=Depositional, [2]=Local, [3]=Regional.
[2]FEATURE(S) *pds*=planar disconformity surface; *kar*=karren; *cb*=solution collapse breccia; *lscb*=large scale solution collapse breccia; *spipe*=solution pipe; *vscrk*=vertical solution cracks; *subhc*=subhorizontal solution cavities; *spthm*=speleothem flowstone; *cpop*=cave popcorn.
[3]Informal member names from Robinson et al. (1989).

units, O and P, which crop out only in the western end of the Sadlerochit Mountains (Fig.1), contain large-scale (10's-of-m-thick) solution collapse breccias (Fig.2f) cut into unaltered host rock. These units document intense karstification of the youngest part of the Katakturuk Dolomite and resulted from an episode of tectonic uplift in Late Proterozoic or Early Cambrian time (Clough et al., 1990) as indicated by the angular unconformity (up to 15 degrees locally) beneath the overlying Nanook Limestone (Cambrian and Ordovician in age).

CONCLUSIONS

With the exception of collapse breccia reported in unit O (Clough, 1989; Robinson et al., 1989), paleokarst features were previously undocumented in the Katakturuk Dolomite. Local and regional paleokarst features indicate that a significant portion (10's to 100's of m) of the original Katakturuk Dolomite succession was altered by karstification and suggest that dissolution may have removed a considerable thickness of strata, particularly along the unconformity between the Katakturuk Dolomite and Nanook Limestone. In a landward direction and farther up the Proterozoic carbonate ramp (north in present coordinates), the Katakturuk Dolomite can be expected to have undergone even more severe degradation by karst processes.

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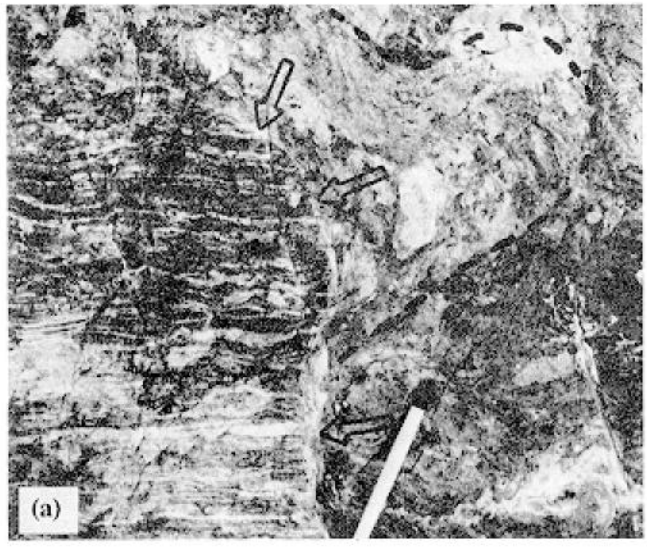
Fig.2. Overleaf. (a) Closeup of karren surface (arrows) in unit I. Surface is scalloped and forms a 10-cm-deep channel cut into peritidal laminite (left side of photo). A subtidal stromatolite (dashed line) grew on the side of the channel during the next marine flooding event and preceded filling of the channel with intraclastic grainstone (right side of photo; pencil for scale). (b) Jagged and pitted karren surface (above hammer) overlain by darker stromatolitic interval, unit I. Note small collapse breccia (arrow). (c) Bedding plane view of exhumed circular solution pipe (arrow) filled with collapse breccia (pencil, located on solution pipe, for scale). (d) Subhorizontal solution cavity filled with multiple generations of speleothemic flowstone, unit H (scale in cm). (e) Cave popcorn formed by spelean cements in solution cavity, unit H (pencil for scale). (f) Polished rock slab of collapse breccia in unit P. Vertical dissolution and mechanical weathering surface (arrow) truncates spelean cement-filled cavity (below arrow) indicating multiple episodes of karst processes occurred during regional karst event (scale in cm).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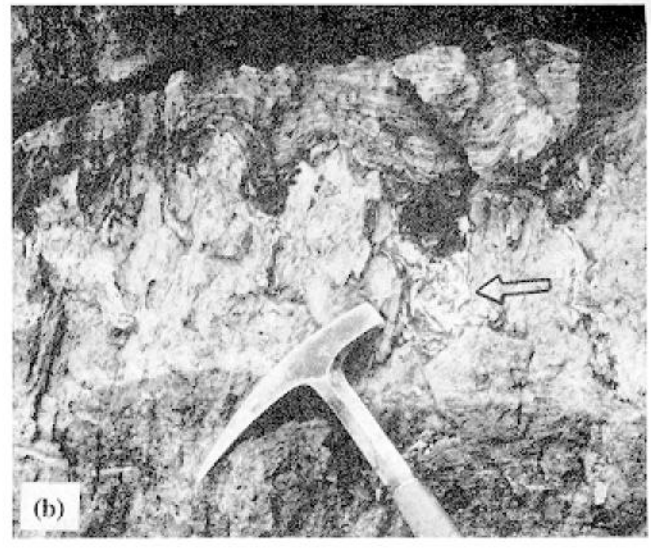
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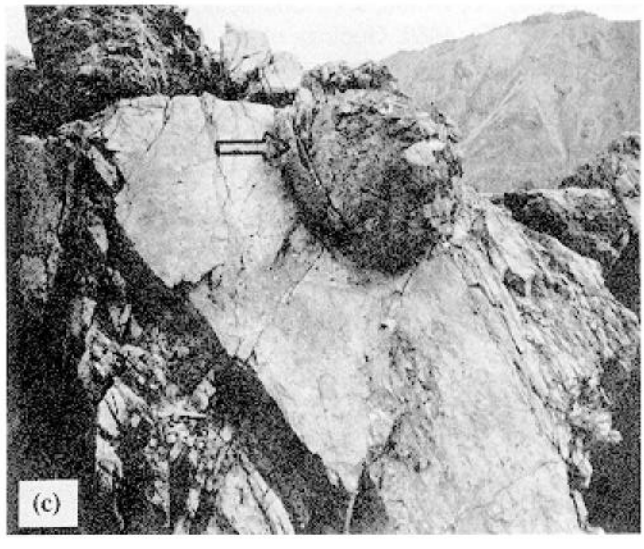
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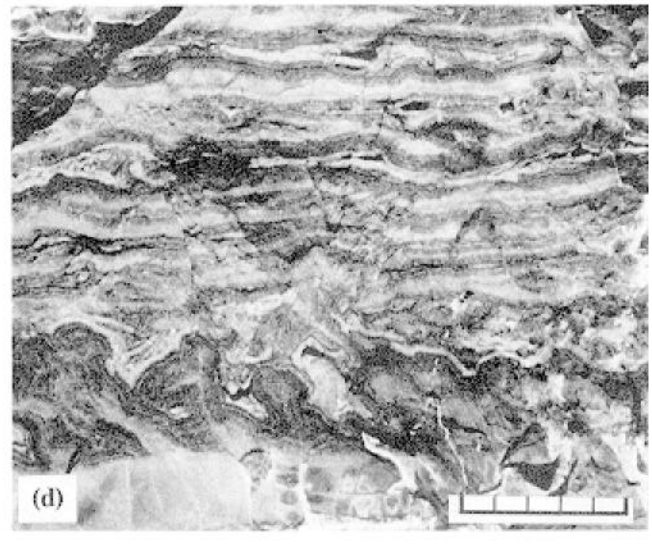
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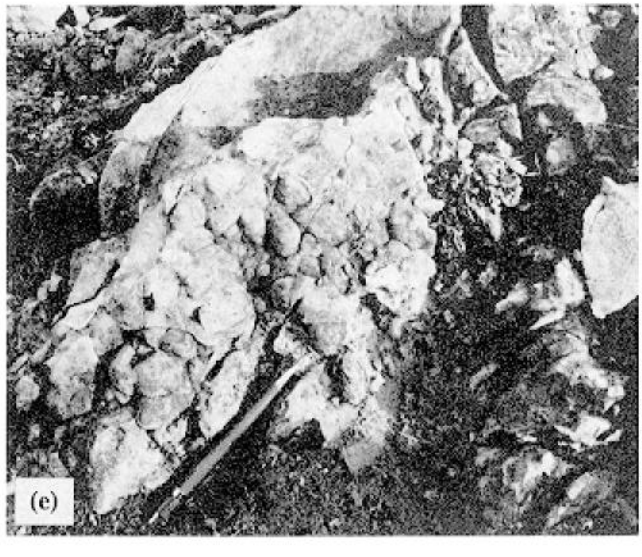
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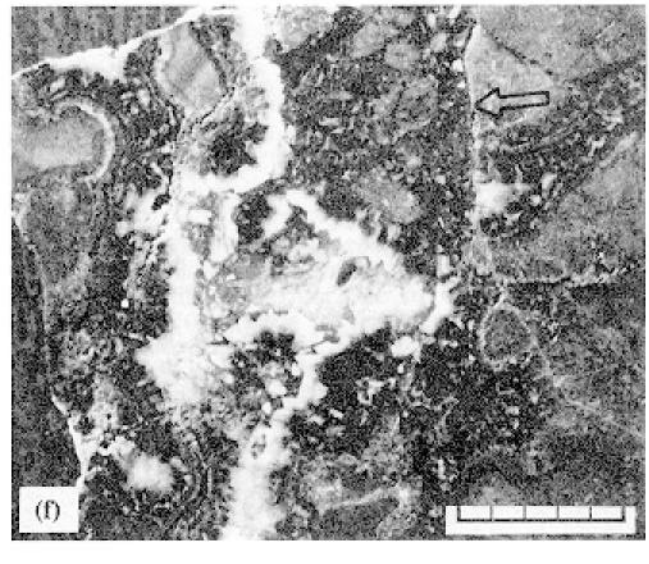
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