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The Upper Ordovician (Katian) strata of the Cincinnati Arch contain numerous mudstone units known locally as 'butter shales' or 'trilobite shales'. Most of these deposits are heavily collected for their excellently-preserved trilobites. The Oldenburg Butter Shale, however, is a previously-undescribed mudstone package from the Waynesville Formation, known only from limited exposure near Oldenburg, Indiana.

The Oldenburg Shale is a 2 m-thick mudstone package with minor beds of shelly packstones, and calcisiltite-filled gutter casts. It contains abundant articulated trilobites. The mudstone portion contains illite, chlorite, quartz, calcite and traces of dolomite and pyrite. In outcrop, the shale exhibits no obvious bedding and breaks conchoidally. When cut and polished, the mudstone shows a mottled fabric, containing Lingulichnus and Chondrites trace fossils. The shelly units contain brachiopods, gastropods, and bryozoans. The gutter casts are 20–30 cm wide, display hummocky stratification, and contain *Lingulichnus*.

Faunally, the Oldenburg is very unlike surrounding Waynesville strata. Instead of being dominated by brachiopods as is typical, the Oldenburg fauna consists of abundant bivalves (*Modiolopsis*, *Ambonychia*, and *Caritodens*), lingulid brachiopods, and the trilobites (*Isotelus*, and *Flexicalymene*, and rare *Amphilichas* in the upper 30 cm). Articulate brachiopods are represented in the shale to a limited extent by the genera *Zygospira* and *Platystrophia*. The shale also contains bryozoans, orthoconic cephalopods, rare crinoids and conulariids. Conodonts and scolecodonts are a major component of the microfauna.

Taphonomy of the fossils, together with sedimentological features, indicates that this butter shale accumulated rapidly as a series of episodes of distal storm-generated mud and silt flows.

Towards the top of the mudstone is a horizon of small concretions, about 7 cm wide. Overlying the butter shale is the pyrite crusted surface of the Mid-Richmondian Unconformity which removes the Oldenburg shale in most other locations. The concretions present at the top of the shale are the likely product of the prolonged sediment starvation accompanying this unconformity.