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First record of Late Albian canaliculate rudist from northern California and re-assessment of *Durania*? *californica* Anderson, 1958

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ABSTRACT

Rudist specimens of Late Albian age from the Upper Chickabally Mudstone Member of the Budden Canyon Formation, Great Valley Sequence, in northern California, are identified as a canaliculate rudist taxon based on shell morphology and mineralogy. Since they are incomplete right valves without cardinal and myophoral parts, their systematic placement is difficult, though their canal characters are similar to those of relatively derived caprinuloidinid rudists such as *Texicaprina* and *Jalpania* (Caprinidae) of the Caribbean/Gulf region. Re-assessement of the holotype specimen of *Durania*? *californica* from the Upper Albian of northern California reveals that it does not belong to the Radiolitidae, but is also a canaliculate rudist. The distribution of canaliculate rudists, probably caprinuloidinids, in the mid-latitudes of the Northeast Pacific suggest that this area belonged to the Tethyan Realm at that time, and a faunal connection existed between the Northeast Pacific and the Caribbean and/or the Central Pacific at least in the Late Albian.

1. Introduction

The distribution of rudist bivalves (Superfamily Hippuritoidea) is often considered as a good indicator of the tropical marine environment and biotic realm (Tethyan Realm) in the Cretaceous, and has been used for many paleobiogeographic and/or paleoceanographic studies (e.g., Kauffman, 1973; Sohl, 1987; Masse, 1992a; Johnson et al., 1996; Johnson, 1999). In the Pacific Coast region of North America, the presence or absence of rudists has been used to interpret environmental and faunal changes in this area (e.g., Saul, 1986), though rudist records from this region are not common. Late Campanian–Early Maastrichtian *Coralliochama* from Baja California, Mexico and the coastal region of northern California, U.S.A. (White, 1885; Marincovich, 1975; Aranda Manteca, 1991; Johnson and Hayes, 1993; Götz et al., 2005) have attracted attention notably from the viewpoint of evaluating the model of large lateral displacement of the western part of the North American continent (e.g., Kodama and Ward, 2001). Recent reports of *Praebarrettia sparcilirata* and a radiolitid in addition to *Coralliochama* from the Campanian of the Santa Ana Mountains, southern California (Filkorn, 2005), and *Pseudopetalodontia* (Monopleuridae), *Tepeyacia* (Polyconitidae) and several species of Caprinuloidinae from the Lower Albian of Baja California (Paynes et al., 2004; Masse et al., 2007a) add new information for further studies.

There are also some rudist records from the Cretaceous sequence of the inland part of northern California and southern Oregon, located to the east of the San Andreas Fault. Lupher and Packard (1930) described *Lithocalamus colonicus*, from probable mid-Cretaceous deposits of southern Oregon. Anderson (1958) described *Durania*? *californica* (Radiolitidae) from northern California and southern Oregon. Although the sequences containing them represent fore-arc basin deposits that accumulated along the western margin of North American craton at that time, and have much potential to contribute to paleogeographic and/or paleobiogeographic discussion, these rudists have received little attention for a long time, because of their rare occurrence and poor preservation in the siliciclastic sequences.

Two canaliculate rudist specimens were newly collected from the Upper Albian of the Great Valley Sequence, northern California. Their systematic placement is discussed in this paper. Furthermore, re-investigation of the holotype specimen of *Durania*? *californica* reveals that this taxon is also a canaliculate rudist, and does not belong to the Radiolitidae. Thus it is evident that canaliculate rudists expanded their distribution to the mid-latitudes of the Northeast Pacific in the Late Albian. These records contribute further to the paleobiogeographic investigation of the Cretaceous Pacific.

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2. Geologic setting

Marine Cretaceous rocks, called the Great Valley Sequence, are well exposed on the surface or underlie younger rocks throughout most of the Ono area, Shasta County (Fig. 1) on the west side of the Sacramento Valley in the foothills of the northern California Coast Ranges. Cretaceous marine rocks in the Ono area, named the Budden Canyon Formation (Murphy et al., 1969), are represented by a thick sequence of fossiliferous clastics, and range in age from Hauterivian? to Turonian. The Budden Canyon Formation includes the most continuous and fossiliferous Lower Cretaceous strata, especially for the Aptian–Albian interval, in the circum-North Pacific region, and has been the object of several biostratigraphic and paleontologic studies (Anderson, 1938; Murphy et al., 1969; Murphy and Rodda, 1996; Amédro and Robaszynski, 2005).

Murphy (1956) and Murphy et al. (1969) subdivided the Budden Canyon Formation into eight members: Recter Conglomerate (Hauterivian?), Ogo (Hauterivian), Roaring River (Barremian), Lower Chickabally Mudstone (Barremian), Huling Sandstone (Upper Aptian), Upper Chickabally Mudstone (Upper Aptian to Upper Albian), Bald Hills (Upper Albian to Cenomanian) and Gas Point members (Cenomanian to Turonian), in ascending order based on characteristic differences in lithology.

Two rudist specimens were newly recovered from the matrix-supported conglomerate of the upper part of Upper Chickabally Mudstone Member, in a section studied along the North Fork of Cottonwood Creek in the Ono area (Loc. 1 of Figs. 1 and 2). Other bivalves such as *Exogyra* and a chondrodontid(?) were found with the rudist specimens. Their occurrence in the matrix-supported conglomerate and also poor preservation of the shells clearly indicates they were probably transported into this area from the nearby shallower shelf. Based on the previous ammonite biostratigraphic studies (Amédro and Robaszynski, 2005), this horizon is assigned to the *Mortoniceras perinflatum* zone (Upper Albian). The specimens are deposited in the California Academy of Sciences (CASG 70794 and 70495). The holotype of *Durania*? *californica* was collected from near the confluence of Huling Creek and North Fork of Cottonwood Creek (Loc. 2) where the lowest part of the Bald Hills Member (Upper Albian: Murphy and Rodda, 1996; Amédro and Robaszynski, 2005) is exposed (Figs. 1 and 2). This specimen is likewise deposited in the California Academy of Sciences (CASG 1346.02).

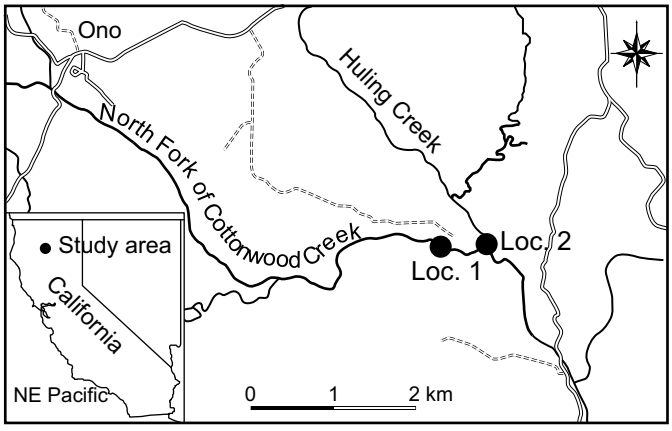

Fig. 1. Locality map of canaliculate rudist specimens in the Ono area on the west side of the Sacramento Valley, northern California Coast Ranges. Two canaliculate rudist specimens were recovered from Loc. 1 (N 40°27′16.0″, W 122°34′05.9″) and the holotype of *Durania*? *californica* from Loc. 2 (N 40°27′14.42″, W 122°33′40.36″).

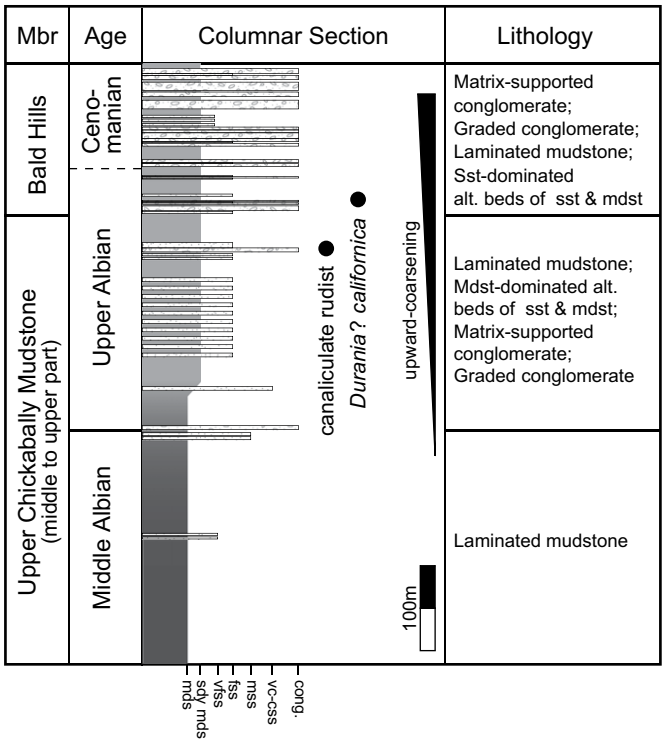

Fig. 2. Generalized lithological columnar section of the Middle Albian–Cenomanian part of the Budden Canyon Formation in the Ono area showing rudist-bearing horizons. The columnar section is based on the research of the exposure along the North Fork of Cottonwood Creek. Geological age based on Murphy and Rodda (1996) and Amédro and Robaszynski (2005).

3. Method—Identification of shell mineralogy—

Mesostructures of the shell wall, such as polygonal cells in the outer shell layer of radiolitids and pallial canals in the inner shell of caprinids, are very useful for the identification of rudists (e.g., Dechaseaux et al., 1969; Skelton and Smith, 2000). Since all rudists had an originally aragonitic inner shell and calcitic outer shell layer (Skelton and Smith, 2000), it is possible to distinguish the inner or outer layer of well-preserved rudist specimens based on shell mineralogy. Here we applied Raman spectroscopy to the Californian rudist specimens.

Raman spectroscopy is an ideal method for identifying polymorphs of materials, because it provides excellent fingerprint spectra specific to each crystal structure. A Raman microprobe in the Geochemical laboratory, Graduate School of Science, The University of Tokyo, was used for this study. Raman spectra were obtained on a 30 cm single polychromator (Chromex, 250is), equipped with an optical microscope (Olympus, BX60), Ar+ ion laser (514.5 nm; ion laser technology, 5500 A), and a charge-coupled devise (CCD) camera with 1024 × 128 pixels (Andor, DU-401-BR-DD SH). The Rayleigh line was removed using a holographic supernotch filter (Kaiser, HIPF-514.5–1.0). The Raman shift was calibrated with a standard sample of naphthalene. The beam size of the incident laser was approximately 2 mm on the sample surface.

4. Identification of Californian rudist specimens

4.1. Shell morphology

Both the new specimens from the Upper Chickabally Mudstone Member are incomplete right valves (Figs. 3A, B), and white in color. They were originally conical, but are now slightly deformed and flattened. Shell heights are 65.2 and 44.6 mm, and maximum