Sano, S, Iba, Y., Skelton, P.W., Aguilar-Pérez, J. and Tanabe, K. 2013. First record of *Immanitas* (Bivalvia, Hippuritida) from northern California, U.S.A. *Caribbean Journal of Earth Science*, **45**, 77-84. © Geological Society of Jamaica. Available online 28th March 2013.

First record of *Immanitas* (Bivalvia, Hippuritida) from northern California, U.S.A.

SHIN-ICHI SANO[1], YASUHIRO IBA[2], PETER W. SKELTON[3], JAVIER AGUILAR-PÉREZ[4] AND KAZUSHIGE TANABE[5]

[1]*Fukui Prefectural Dinosaur Museum, Katsuyama, Fukui 911-8601, Japan; e-mail ssano@dinosaur.pref.fukui.jp*
[2] *Department of Natural History Sciences, Hokkaido University, Sapporo, Hokkaido 060-0810, Japan*
[3]*Department of Environment, Earth and Ecosystems, The Open University, Milton Keynes MK7 6AA, UK*
[4]*Facultad de Ciencias de la Tierra, Universidad Autónoma de Nuevo León, Unidad Linares, Mexico*
[5] *University Museum, The University of Tokyo, Tokyo 113-0033, Japan*

ABSTRACT. A caprinoid rudist, *Immanitas anahuacensis* Palmer is described from the Budden Canyon Formation in northern California, U.S.A. This is the first unambiguous record of this genus outside central Mexico. The supposed Late Albian age of this genus in Mexico is confirmed by the discovery of the Californian specimen in the Mortoniceras perinflatum zone, based on the well-established ammonoid biostratigraphy of the area. A faunal link between the mid-latitudes of the northeastern Pacific and the terranes of central Mexico thus existed at least in Late Albian times.

Key words: *Immanitas*, Caprinuloideidae, northern California, Budden Canyon Formation, Late Albian.

1. INTRODUCTION

The Caprinoidea d'Orbigny 1847 [see Skelton (this volume) for higher classification of rudists] represents the most notable component of mid-Cretaceous rudist evolution (the 'Caprinid Phase' in Skelton 2003). Its largely Caribbean–Pacific family, the Caprinuloideidae Damestoy 1971 (= Coalcomaninae Coogan 1973 = Caprinuloidinae Mac Gillavry 1970) flourished in Barremian–Albian times, allowing the establishment of a biostratigraphic zonation for the Caribbean region (e.g., Scott and Filkorn, 2007).

The presence of a Late Albian canaliculate rudist in northern California, located in the mid-latitudes of the northeastern Pacific at that time, was only recently recognized (Iba et al., 2009). Its systematic assignment, however, remains unsolved, though its possible relationship to derived caprinuloideid rudists, such as *Texicaprina*, *Jalpania* or a related form, was suggested. During the geological and palaeontological studies of the Cretaceous of the northeastern Pacific (e.g., Iba et al., 2009, 2011a, 2011b), one of the authors, Y. Iba, discovered the undescribed specimen of a canaliculate rudist from northern California (CASG 60852), similar to the type specimen of *Immanitas rotunda* Palmer, in the depository of the California Academy of Sciences. Its systematic placement is discussed in this paper.

Immanitas is characterized by a very large, arcuate equivalve shell of recumbent morphotype, which is almost completely filled with small tabulate canals of round or polygonal cross-section (Palmer, 1928; Coogan, 1977). Palmer (1928) established two species: *I. anahuacensis* and *I. rotunda* from Paso del Rio, Colima Province, Mexico. Since the latter species had been known only from a single incomplete specimen (a short fragment) recovered from Colima (Palmer, 1928) and another tentatively-assigned specimen (*I.* sp.?, cf. *I. rotunda*) from a well in Texas (Coogan, 1977), its attribution to the genus *Immanitas* has been questioned in many previous studies, including that of Palmer (1928). Furthermore, the family assignment of the genus *Immanitas* has been problematic because of poor preservation of the specimens and the consequent difficulty in recognizing the myocardinal arrangement, such that *Immanitas* was placed in the section of "Family UNCERTAIN" in the Bivalvia volumes of the *Treatise* (Dechaseaux et al., 1969) and in Coogan (1977). Recently, Aguilar-Pérez (2008) discovered several new localities with *Immanitas* from the El Abra, Tamabra and Morelos formations in central Mexico and discussed its morphology in detail, based on the observation of many specimens recovered from these and the type localities. Furthermore, he concluded that this genus is composed of a single species *I. anahuacensis*, and belongs to the Caprinuloideidae. Although the age of *Immanitas* was originally assigned to the Cenomanian by Palmer

(1928), Filkorn (2002) reviewed the age of the type locality of *Immanitas* in detail and concluded its age to be Middle or Late Albian. Aguilar-Pérez (2008) considered the age of *Immanitas* to be Late Albian based on the age of rudist assemblages co-occurring with this genus, i.e. *Toucasia texana* (Roemer), *Kimbleia capacis* Coogan, *Mexicaprina cornuta* Coogan, *Texicaprina* sp. and *Ichthyosarcolites alata* (Filkorn) from the El Abra Formation, and *To. texana*, *Douvillelia skeltoni* Alencáster and Pantoja-Alor, *K. capacis*, *M. cornuta*, *Planocaprina trapezoides* Palmer, *I. alata* and "caprínido gen. indet., sp. (Aguilar, 2008)" from the Morelos Formation.

Here we describe a new specimen of a Californian canaliculate rudist as *Immanitas anahuacensis* Palmer. The discovery of *Immanitas* from northern California is the first unambiguous record of this genus outside central Mexico, since Aguilar-Pérez (2008) did not confirm the attribution of the Texan specimen to this genus. The ammonoid biostratigraphy has been established for the Budden Canyon Formation in northern California (e.g., Murphy and Rodda, 1996; Amédro and Robaszynski, 2005), and a Late Albian (the Mortoniceras perinflatum zone) age is safely inferred for the Californian *Immanitas* specimen. This finding is concordant with the opinion of Aguilar-Pérez (2008) about the age of Mexican *Immanitas*. Thus a faunal link between the northeastern Pacific and the terranes of central Mexico can be supposed at least for Late Albian times.

2. GEOLOGICAL SETTING

A Lower to mid-Cretaceous, thick marine fossiliferous sequence, called the Budden Canyon Formation, which was deposited in the Great Valley forearc basin is widely distributed along the west side of the Sacramento Valley in northern California (e.g., Anderson, 1938, 1958; Murphy, 1956; Murphy et al., 1969; Ingersoll, 1982; Surpless et al., 2006). The Budden Canyon Formation is subdivided into eight members: the 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 (Murphy, 1956; Murphy et al., 1969), and it has been an important target for many biostratigraphic and palaeontologic studies (e.g., Anderson, 1938; Murphy and Rodda, 1996; Amédro and Robaszynski, 2005).

The specimen here described was collected during a palaeontological impact evaluation of a proposed reservoir site in the Cottonwood District of northern California sponsored by the California Division of Water Resources (Rodda and Murphy, 1987), and is now stored in the California Academy of Sciences. The locality record archived with the specimen is "California, Shasta Co., N bank of N Cottonwood Creek. 50yds downstream from Nielson Rd and near mouth of Huling Cr. 1760' W of E boundary and 2825' S of N boundary of SE corner Sec 17, T30N, R6W MDBM. " The matrix of the specimen is composed of matrix-supported conglomerate with some small shell fragments. According to the comparison of these geographical and lithological data with our own data, the provenance of the specimen can be attributed to either of two conglomeratic beds in the upper part of Upper Chickabally Mudstone Member (Loc. 1 in **Figures 1 and 2**) or the lowest part of the Bald

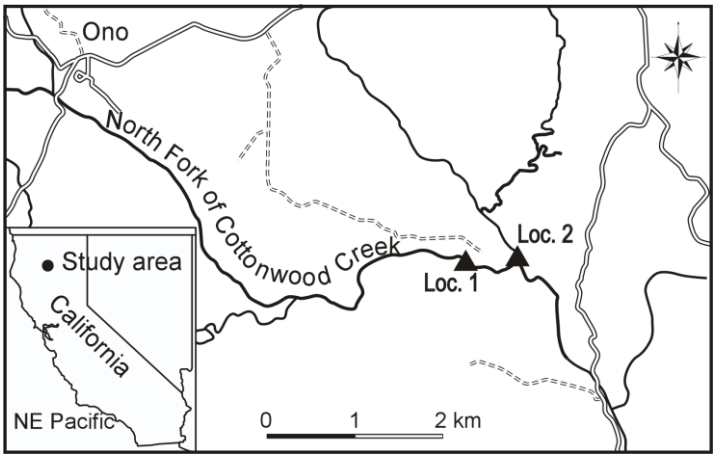

Figure 1. Locality map of *Immanitas anahuacensis* Palmer in the Ono area on the west side of the Sacramento Valley, northern California Coast Ranges, U.S.A. The specimens was recovered either from Loc. 1 (N 40˚27′16.0″, W 122˚34′05.9″) or Loc. 2 (N 40˚27′14.42″, W 122˚33′40.36″).

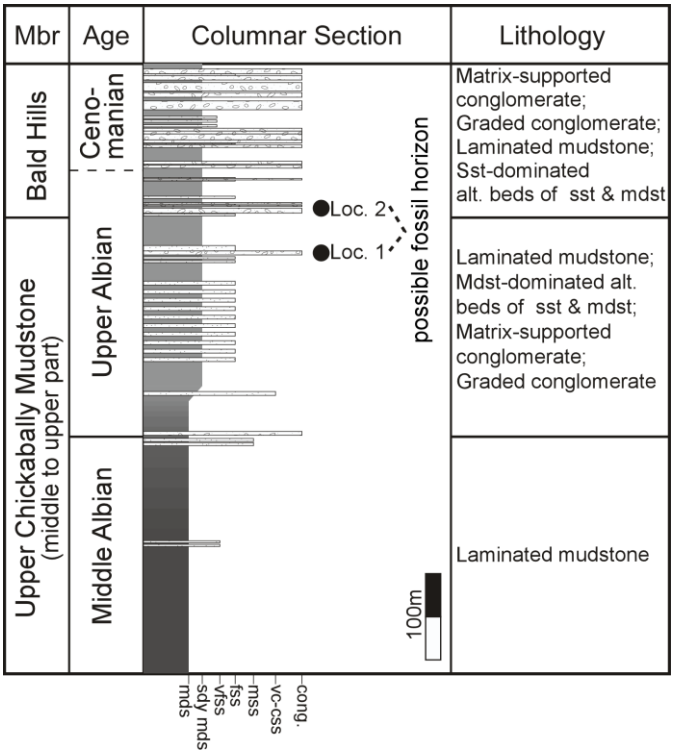

Figure 2. Generalized lithological columnar section of the Middle Albian–Cenomanian part of the Budden Canyon Formation in the Ono area, northern California Coast Ranges, based on the research of the exposure along the North Fork of Cottonwood Creek (Figure 1). Possible *Immanitas*-bearing horizons (either Loc. 1 or Loc. 2) are shown. Geological ages after Murphy and Rodda (1996) and Amédro and Robaszynski (2005).

Hills Member (Loc. 2 in **Figures 1 and 2**). These localities are probably the same as, or very close to the localities of the canaliculate rudist described by Iba et al. (2009). Since the specimen here described was discovered in a museum collection, its field context and associated taxa are unknown. However, Iba et al. (2009) reported the presence of other bivalves of shallow marine origin, such as *Exogyra* and a chondrodontid (?) together with their rudist specimens. The rudist and other bivalve specimens were poorly preserved, and were recovered from the matrix of a conglomerate bed and not in the gravels. Furthermore, there is no indication of the presence of reworked fossils from older strata in the conglomerate beds. Thus these shallow marine bivalves were probably derived from a penecontemporaneous assemblage, and transported into this area from the nearby shallower shelf. Based on the previous ammonoid biostratigraphic studies (e.g., Murphy and Rodda, 1996; Amédro and Robaszynski, 2005), both of these supposed rudist-bearing horizons are assigned to the Mortoniceras perinflatum zone (Upper Albian).

3. SYSTEMATIC PALAEONTOLOGY

Superfamily Caprinoidea d'Orbigny 1847
Family Caprinuloideidae Damestoy 1971
Genus *Immanitas* Palmer 1928

***Immanitas anahuacensis* Palmer, 1928**
Figures 3, 4

v.* 1928 *Immanitas anahuacensis* n. sp.: Palmer p. 30-32; pls. 1-4.
v. 1928 *Immanitas rotunda* n. sp.: Palmer p. 32; pl. 5, fig. 1
v. 1958 *Durania? californica* n. sp.: Anderson p. 126-127; pl. 1, figs. 1-2.
? 1977 *Immanitas* sp.?, cf. *I. rotunda* Palmer; Coogan p. 68; pl. 15, figs. 7a, b.
v. 2008 *Immanitas anahuacensis* Palmer; Aguilar Pérez p. 98-104, fig. 58.
v. 2009 a canaliculate rudist; Iba et al. p. 541-544, figs. 3, 5.

Material. An incomplete left valve (CASG 60852) from the north bank of North Cottonwood Creek, Shasta County, northern California.

Description. The specimen is an incomplete left valve of a large individual, partly exposed on the surface of a rock specimen, and now broken into several pieces (**Figure 3A**). Possibly only the umbonal part of the arcuate shell is preserved. The umbo shows a low spiral form, curved in an anterior direction. The thin outer shell layer showing growth lines is preserved only in the postero-dorsal part; for the most part only the inner shell layer with canals is observed (**Figures 3B, 4A**). The shell is almost completely filled with small (up to about 1 mm in diameter), tabulate, polygonal canals, except for a single row of pyriform canals along the shell margin (**Figures 3B–C, 4B**). In cross section, the shell is elongated dorso-ventrally (up to about 78 mm in the section of **Figure 4B**). The anterior side of the shell

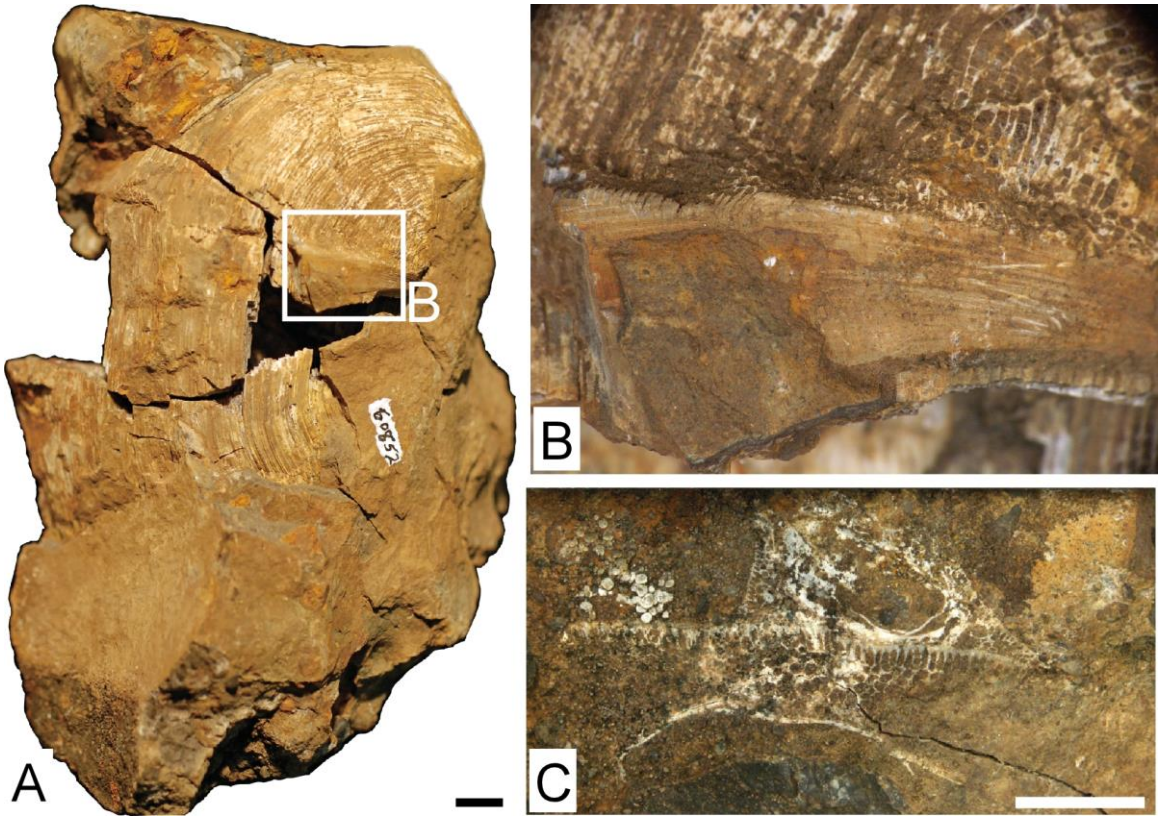

Figure 3. ***Immanitas anahuacensis*** **Palmer (CASG 60852) from Upper Albian part of the Budden Canyon Formation in northern California. A: Left valve exterior, partly exposed on the surface of the rock specimen, and now broken into several pieces. Note that outer shell layer is partly preserved in its postero-dorsal part (labelled B). B: Thin outer shell layer showing growth lines covers the pyriform canals along the margin of inner shell layer. Small, tabulate, polygonal canals fill the shell below the pyriform canals. C: Transverse section of the anterior part of the rudist shell. Note a single row of pyriform canals along the shell margin and polygonal canals in the shell wall. Small individual attached at top. Scale = 1 cm.**

is nearly flat, and the antero-ventral corner is possibly projected, while, by contrast, the dorsal to posterior side is convex and rounded (**Figure 4B**). The body cavity is small; the presence of tabulae is not yet recognized in the body cavity. The anterior tooth, represented by a U-shaped white re-crystallized part, is situated in the centre of the shell, dorsal to the body cavity; the opening of this U is inclined antero-dorsally. The other two re-crystallized parts situated posteriorly to the U-shaped anterior tooth correspond (dorsally) to the posterior tooth and (ventrally) to the posterior myophore . These re-crystallized parts are traced laterally inside the shell along the growth direction, and grade into the parts filled with relatively large (up to about 2 mm in diameter) polygonal canals. The anterior myophore is represented by smaller-sized canals than those of the inner part of the shell and lies on the anterior side of the anterior tooth and body cavity. It is elongated antero-dorsally alongside the nearly flat anterior side of the shell (**Figure 4C–E**). Sediment fills the space between the anterior and posterior teeth and posterior myophore, and probably represents the central tooth socket. No ligament groove and trace can be identified.

The appearance of the anterior tooth accompanied by sediment in transverse section (**Figure 4B**) gives a misleading impression of the U-shaped anterior tooth of the left valve being inserted in the sediment-filled anterior tooth socket of the right valve. However, according to the exterior views of **Figure 3A and 4A**, the transverse section of **Figure 4B** represents an adumbonal view, with the anterior tooth on the right and posterior tooth on the left, thus confirming that the specimen is indeed a left valve. Moreover, the position of the transverse section of **Figure 4B** is too far from the commissure to suppose the presence there of inserted teeth from the opposite valve. Furthermore, in another transverse section of part of the anterior tooth in **Figure 4E**, which is nearer to

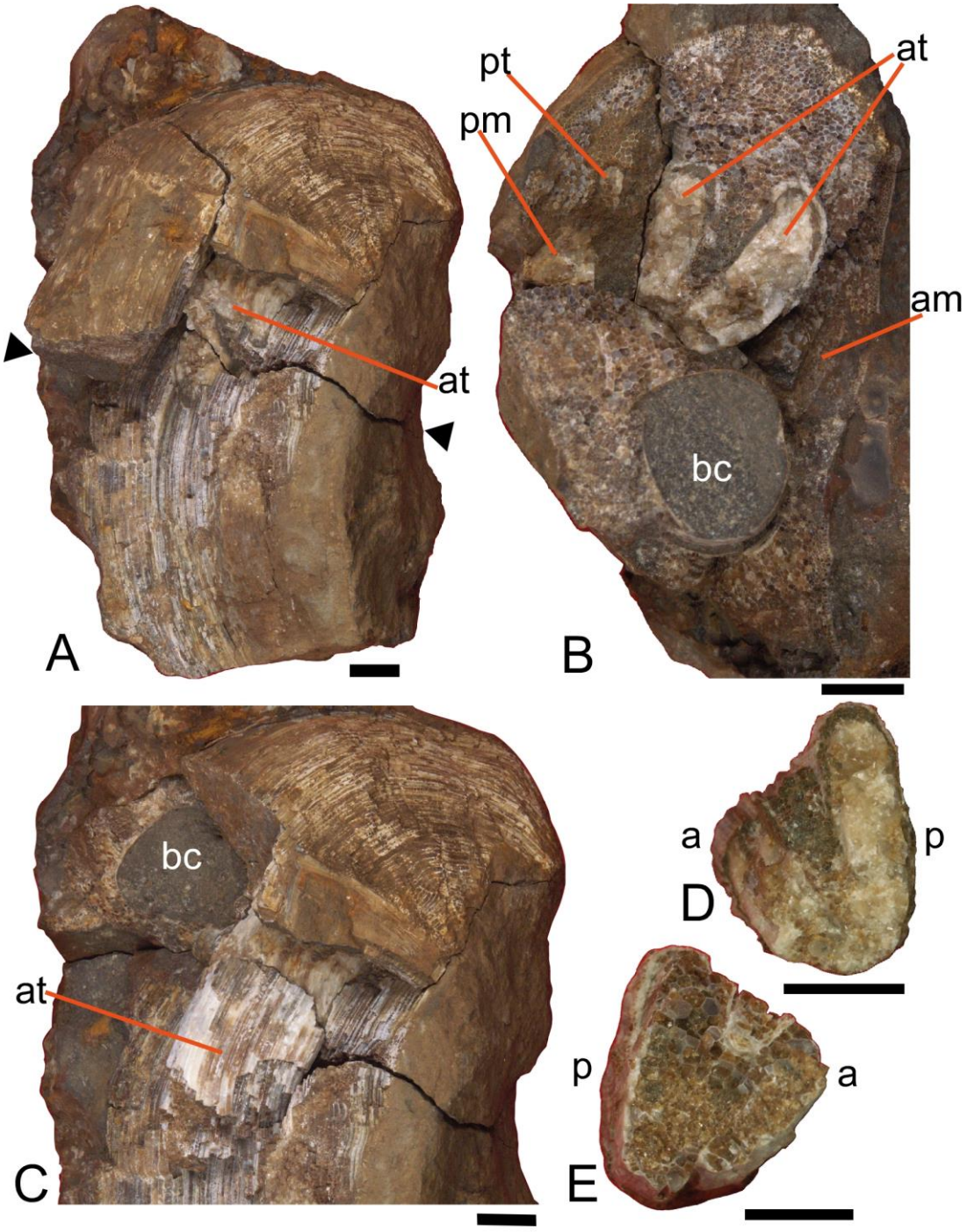

Figure 4. Internal characters of the shell of *Immanitas anahuacensis* Palmer (CASG 60852) from Upper Albian part of the Budden Canyon Formation in northern California. at, pt, am, pm, bc, a and p represent anterior tooth, posterior tooth, anterior myophore, posterior myophore , body cavity, anterior side and posterior side, respectively. A: Longitudinal section showing the development of canals inside the shell. Triangles indicate the position of transverse section of Figure 4B. B: Transverse section. Adumbonal view. Note small polygonal canals filling almost all of the shell, and re-crystallized parts representing anterior (U-shaped) and posterior teeth and posterior myophore. C: Longitudinal section showing anterior tooth traced laterally inside the shell along the growth direction. D: Separated anterior tooth extension corresponding to the part labelled 'at' in Figure 4C. Re-crystallized part is directly continued to the U-shaped anterior tooth in Figure 4B. Abumbonal view. Note that sediment fills some canals of the inner part of the shell. E: U-shaped anterior tooth filled with relatively large polygonal canals. Adumbonal view. It changes laterally to the U-shaped re-crystallized part of anterior tooth in Figure 4B and 4D. Scale = 1 cm.

the commissure than that in **Figure 4B**, the anterior tooth merges into the inner shell without accompanying sediment. Since sediment also fills some of the canals in the inner parts of the shell, which are located near but outside the anterior tooth (**Figure 4D**), it is evident that sediment was able to fill cavities in broken parts of the shell far from the commissure.

Discussion. The general morphological characters of the Californian specimen, such as the large arcuate shell almost completely filled with small polygonal canals, small sized body cavity, and recumbent form indicated by the flatness of the anterior (probably lower) side of the shell, are similar to those of *I. anahuacensis* described in Palmer (1928). In addition, the U-shaped re-crystallized part in the centre of the shell of the Californian rudist is its notable character, as also seen in the holotype specimen of *I. rotunda* Palmer. However, since a similar U-shaped anterior tooth socket in the right valve, corresponding to the anterior tooth of the left valve, has been recognized in several specimens of *I. anahuacensis*, it is now supposed that *I. rotunda* is in fact a fragment of *I. anahuacensis* (Aguilar-Pérez, 2008). Although some specimens of *Mexicaprina cornuta* Coogan, 1973 also have a similar U-shaped anterior tooth socket (Aguilar-Pérez, 2008), the small size of the latter's shell, and the morphology and size of the canals are different from those of *Immanitas*. Nevertheless, the projection of the shell in the ventral part in *M. cornuta* suggests some similarity with the Californian specimen. We assign the Californian specimen to *I. anahuacensis* here. It should be noted that the U-shaped re-crystallized part passes laterally into the U-shaped part filled with relatively large polygonal canals, suggesting that such a U-shaped structure might not be recognized easily in most parts of the shells. This may be the reason why the specimens with U-shaped re-crystallized part similar to "*I. rotunda*" have been very rare compared with *I. anahuacensis*.

Although the Californian specimen preserves nearly all of the shell in cross section, the diagnostic 'ropy' fold ('W') in the upper (posterior) surface of the shell and the three large ventral cavities (X, Y and Z) in the lower surface of the shell that are mentioned in the original description of *I. anahuacensis* in Palmer (1928), cannot be recognized. The same appears to be true of the type specimen of '*I. rotunda*', contrary to Palmer's interpretation of a submerged version of the 'ropy' fold ('W'), and homology of the X and Y cavities with the U-shaped structure in '*I. rotunda*', which appears to be erroneous. Thus the presence of the 'ropy' fold and ventral cavities is probably variable among *I. anahuacensis* individuals. Aguilar-Pérez (2008) has already pointed out the individual (and not ontogenetic) variation of the numbers of cavities in *I. anahuacensis* specimens. However, the absence of tabulae in the body cavity of the Californian specimen is unusual for *Immanitas*. Further work is necessary to resolve the individual variations of *I. anahuacensis* especially in the characters of the body cavity and ventral half of the shell, which still leaves open the possibility that the Californian specimen belongs to a new taxon similar to *I. anahuacensis*.

Comparison with previously known canaliculate rudist specimens from northern California (Iba et al., 2009) are briefly discussed here. The relatively large and thick shell, filled with small, tabulate, polygonal canals, of the holotype of '*Durania? californica* Anderson, 1958' suggests its possible similarity with *I. anahuacensis*. The presence of a single row of pyriform canals in the shell margin and polygonal canals in most parts of the inner shell layer shown in a paratype specimen of '*Durania? californica*' (Anderson, 1958, plate 1, figure 2), similar to **Figure 3C** of the specimen here described, also support this idea. Iba et al. (2009) reported two incomplete specimens of canaliculate rudists from northern California from the same, or very nearby localities with the specimen here described. They also have small, tabulate, polygonal canals, which fill almost all parts of the preserved shells. Such characters are possibly similar to those of *Immanitas* as already discussed in Iba et al. (2009). Thus these specimens are also tentatively assigned to *I. anahuacensis* here, though their incompleteness, small size and possible conical shape are problematical.

Stratigraphical Range and Geographical Range. Late Albian of central Mexico, northern California, and possibly southern Oregon, based on the description of "*Durania? californica*" by Anderson (1958).

4. CONCLUSIONS

A new specimen of a caprinoid rudist, *Immanitas anahuacensis* Palmer, which is stored in the California Academy of Sciences, is described from northern California. This genus has been previously known only from central Mexico. A Late Albian (Mortoniceras perinflatum zone) age of this genus is indicated by the well-established ammonoid biostratigraphy of its provenance, the Budden

Canyon Formation in the Ono area. Thus, a faunal link between the mid-latitudes of the northeastern Pacific and the terranes of central Mexico is inferred at least for Late Albian times.

Acknowledgements. Thanks are extended to J. F. DeMouthe, P. Roopnarine and Y. Shigeta for help in observing northern California fossil collections in the California Academy of Sciences. We would like to thank R. W. Scott and S. F. Mitchell for their constructive reviews. This research was supported by JSPS Fellowship (no. 08119 in 2009 and 2010 for Y. Iba), JSPS grant-in-aid for scientific research (no. 18403013 in 2006–2008 for K. Tanabe; no. 23840002 in 2011–2012 for Y. Iba) and a part of the scientific research fund of the 21st Century Center of Excellence Program to the University of Tokyo (G3, leader T. Yamagata).

REFERENCES

Aguilar-Pérez, J. 2008. *Rudistas del Cretácico Inferior y Medio, Barremiano?–Cenomaniano, Noreste y Centro de México.* Unpublished Ph.D. Thesis, Universitat Autònoma de Barcelona. 139 pp.

Alencáster, G. and Pantoja Alor, J. 1998. Two new Lower Cretaceous rudists (Bivalvia-Hippuritacea) in the Huetamo region; Southwest Mexico. *Geobios, Mémoire spécial*, **22**, 15-28.

Amédro, F. and Robaszynski, F. 2005. Corrélation des successions de l'Albien par les ammonites entre la Province Nord-Pacifique et les Provinces européenne et arctique du Domaine boréal: zonation, eustatisme et paléobiogéographie. *Geobios*, **38**, 585-607.

Anderson, F. M. 1938. Lower Cretaceous deposits in California and Oregon. *Geological Society of America, Special Paper*, **16**, 339 pp., Boulder, Colorado.

Anderson, F. M. 1958. Upper Cretaceous of the Pacific Coast. *Geological Society of America, Memoir*, **71**, 378 pp., Boulder, Colorado.

Coogan, A. H. 1973. New rudists from the Albian and Cenomanian of México and south Texas. *Revista del Instituto Mexicano del Petroleo*, **5**, 51-83.

Coogan, A. H. 1977. Early and middle Cretaceous Hippuritacea (rudists) of the Gulf Coast. In: **Bebout, D. G. and Loucks, R. G. (Eds.)**, *Cretaceous Carbonates of Texas and Mexico, Applications to Subsurface Exploration. Report of Investigations*, **89**, 32–70, Bureau of Economic Geology, University of Texas, Austin.

Damestoy, G. 1971. Essai de classification phylogénique des caprinidés (Lamellibranches). *Bulletin du Muséum National d'Histoire Naturelle*, Série 2, **42**, 1003-1008.

Dechaseaux, C., Cox, L. R., Coogan, A. H. and Perkins, B. F. 1969. Superfamily Hippuritacea Gray, 1848. In: **Moore, R.C. (Ed.)**, *Treatise on Invertebrate Paleontology*, Part **N**, *Mollusca* **6**, *Bivalvia*, **2**, N749–817, University of Kansas, Lawrence, Kansas and Geological Society of America.

Filkorn, H. F. 2002. A new species of *Mexicaprina* (Caprinidae, Coalcomaninae) and review of the age and paleobiogeography of the genus. *Journal of Paleontology*, **76**, 672-691.

Iba, Y., Sano, S., Skelton, P. W., Kagi, H. and Tanabe, K. 2009. First record of Late Albian canaliculate rudist from northern California and re-assessment of *Durania*? *californica* Anderson, 1958. *Cretaceous Research*, **30**, 540-546.

Iba, Y., Mutterlose, J., Tanabe, K., Sano, S., Terabe, K. and Misaki, A. 2011a. Belemnite extinction and the origin of modern cephalopods 35 m.y. prior to the Cretaceous–Paleogene event. *Geology*, **39**, 483-486.

Iba, Y., Sano, S. and Tanabe, K. 2011b. A Tethyan bivalve, *Neithea* (Cretaceous pectinid) from northern California, and its biogeographic implications. *Paleontological Research*, **15**, 79-84.

Ingersoll, R. V. 1982. Initiation and evolution of the Great Valley forearc basin of northern and central California, USA. In: **Leggett, J. K. (Ed.)**, *Trench–forearc geology; sedimentation and tectonics on modern and ancient active plate margins. Geological Society, London, Special Publications*, **10**, 459–467, London.

Mac Gillavry, H. J. 1970. Geological history of the Caribbean, 1. *Koninklijke Nederlandse Akademie van Wetenschappen, Proceedings*, **B73**, 64–83.

Murphy, M. A. 1956. Lower Cretaceous stratigraphic units of northern California. *American Association of Petroleum Geologists, Bulletin*, **40**, 2098–2119.

Murphy, M. A. and Rodda, P. U. 1996. The Albian-Cenomanian boundary in northern California. *Geological Society of America, Bulletin*, **108**, 235-250.

Murphy, M. A., Rodda, P. U. and Morton, D. M. 1969. Geology of the Ono quadrangle, Shasta and Tehama counties, California. *California Division of Mines and Geology, Bulletin*, **192**, 28 pp.

Orbigny, A. D. d'. 1847. Sur les Brachiopodes ou Palliobranches (deuxième mémoire). *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences*, **25**, 266-269.

Palmer, R. H. 1928. The Rudistids of Southern Mexico. *Occasional Papers of the California Academy of Science*, **14**, 137 pp.

Rodda, P. U., and Murphy, M. A. 1987. Paleontological Survey: Hulen Reservoir Project. *California Department of Water Resources, Northern District*, 305 pp.

Roemer, F. 1852. *Die Kreidebildungen von Texas und ihre organischen Einschlüsse*. Adolf Marcus, Bonn, 100 pp., 11 pls.

Scott, R. W. and Filkorn, H. F. 2007. Barremian–Albian rudist zones, U.S. Gulf Coast. In: **Scott, R. W. (Ed.)**, *Cretaceous Rudists and Carbonate Platforms: Environmental Feedback. SEPM Special Publication*, **87**, 167–180.

Skelton, P. W. 2003. Rudist evolution and extinction – a North African perspective. In: **Gili, E., Negra, H. and Skelton, P. W. (Eds.)**, North African Cretaceous carbonate platform systems. *NATO Science Series IV. Earth and Environmental Sciences*, **28**, 215-227, Kluwer Academic Publishers.

Skelton, P. W. 2013 (this volume). Rudist classification

for the revised Bivalvia volumes of the Treatise on Invertebrate Paleontology. *Caribbean Journal of Earth Science*, **45**, 9-33.

Surpless, K. D., Graham, S. A., Covault, J. A. and Wooden, J. L. 2006. Does the Great Valley Group contain Jurassic strata? Reevaluation of the age and early evolution of a classic forearc basin. *Geology*, **34**, 21-24.

Accepted 11th January 2013