CIRCUM-PACIFIC CORRELATION OF ARGENTINE EARLY AND MIDDLE JURASSIC BIVALVE ZONES

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ABSTRACT

A correlation of bivalve biostratigraphic units recognized in different regions around the Pacific is attempted. The same bivalve groups and frequently the same genera are used in both northern and southern regions, involving monotaceans and pectinaceans for the Lower Jurassic and inoceramids for the Middle Jurassic. Five Lower Jurassic assemblage zones have been recognized in Argentina. A *Meleagrinella* faunule is found in Toarcian-Aalenian deposits and a *Propeamussium andium* Assemblage Zone spans the lowest Bajocian. One faunule and four assemblage zones are proposed for the Bajocian-Callovian of Argentina based on the distribution of inoceramid faunas: *Retroceramus* cf. *inconditus* faunule ; *Parainoceramus*? *westermanni*, *R. marwicki*, *R. patagonicus* and *R. stehni* Assemblage Zones. All of them are accurately calibrated against the local ammonite zonation. Relation of these bivalve assemblages with Northeast and Far-East Russia bivalve zonations shows approximately equivalent distributions in time for similar groups, though most South American assemblages consistently seem to be somewhat younger than their Boreal counterparts. The comparison shows that direct correlation between bivalve zones is possible, especially between relatively close regions. Furthermore, knowledge obtained from Andean faunas can be applied to adjust the age of local units based on bivalves, such as the New Zealand stages.

KEY WORDS : BIVALVES, BIOSTRATIGRAPHY, EARLY JURASSIC, MIDDLE JURASSIC, ARGENTINA, CIRCUM-PACIFIC.

RÉSUMÉ

On propose une corrélation des unités biostratigraphiques de bivalves dans différentes régions autour du Pacifique. Les mêmes groupes sont utilisés, souvent les mêmes genres, tant pour les régions du Nord que pour les régions du Sud, dont des Monotacea et des Pectinacea pour le Jurassique inférieur et des inocéramidés pour le Jurassique moyen. Cinq zones d'association ont été recounnues en Argentine au Jurassique inférieur. Une faunule à *Meleagrinella* se trouve dans des dépôts toarciens-aaléniens et une zone d'association à *Propeamussium andium* existe dans le Bajocien basal. Une faunule et quatre zones d'association sont proposées pour le Bajocien-Callovien de l'Argentine sur la base de la distribution des faunes d'inocéramidés : faunule à *Retroceramus* cf. *inconditus*, zones d'association à *Parainoceramus*? *westermanni*, à *R. marwicki*, à *R. patagonicus* et à *R. stehni*. Toutes ces unités sont comparées et corrélées de façon précise avec la zonation locale d'ammonites. La relation de ces associations de bivalves avec la zonation de bivalves du Nord-Est et de l'Est de la Russie montre des distributions a peu près équivalentes dans le temps pour les groupes similaires, bien que la plupart des associations sud-américaines semblent être un peu plus jeunes que ses correspondantes boréales. La comparaison montre qu'une corrélation directe entre les zones de bivalves est surtout possible entre des régions relativement proches. De plus, l'apport des faunes andines permet de mieux ajuster l'âge d'unités locales fondées sur les bivalves, tels que les étages de la Nouvelle-Zélande.

MOTS-CLÉS : BIVALVES, BIOSTRATIGRAPHIE, JURASSIQUE INFÉRIEUR, JURASSIQUE MOYEN, ARGENTINE, CIRCUM-PACIFIQUE.

INTRODUCTION

Detailed knowledge of Jurassic bivalves has increased their use in biostratigraphy in many regions, where they supplement the ammonoid zonation. To the successful buchiid zonation for the Upper Jurassic, other useful bivalve groups have been added, notably monotaceans and pectinaceans for the Lower Jurassic and inoceramids for the Middle Jurassic.

In circum-Pacific regions formal biostratigraphic units based on bivalves have been recognized in Northeast and Far-East Russia (e.g. Polubotko & Sey 1981 ; Sey 1984 ; Sey & Kalacheva 1980, 1985, 1988 ; Shurygin 1991) and southern South America (Damborenea 1990 and *in* Riccardi *et al.* 1990a). Argentinian bivalve units are accurately calibrated against the local ammonite zonation (Riccardi 1984 ; Riccardi *et al.* 1988a, 1988b, 1990a, 1990b, 1990c) and their distribution in space and time has been summarized by Damborenea (1990, 1991). In New Zealand bivalves have great stratigraphical value and they are even used to mark the lower boundaries of local stages (Marwick 1951, 1953 ; Fleming & Kear 1960 ; Speden 1970 ; Stevens 1978 ; Stevens & Speden 1978). A series of bivalve assemblages has also been reported from China (Wang & Sun 1983 ; Wang 1988), whereas the biostratigraphical potential of Lower and Middle Jurassic bivalve faunas from Alaska, western North America and Japan has not been fully developed yet.

Since bivalve biostratigraphical units are commonly thought to have only local or, at best, regional value, the available information from different regions is seldom compared. Such a comparison and correlation is here attempted for the circum-Pacific regions. The treatment follows the chronological order of Argentinian units, with main results also summarized in Table I.

BIOSTRATIGRAPHY AND CORRELATION

PALMOXYTOMA FAUNULE

The knowledge of Hettangian circum-Pacific bivalve faunas is still poor. In Argentina and Chile an ill-defined faunule with *Palmoxytoma* sp. (Riccardi *et al.* 1988a, in press ; Damborenea 1991, 1992) and "*Inoceramus*" sp. (Tilmann 1917 ; Escobar 1980) can be recognized. This faunule also contains *Camptonectes*? cf. *subulatus* (MÜNSTER) and is associated with ammonites of the *Waehneroceras-Schlotheimia* and *Badouxia canadensis* Ammonite Zones. It can be correlated to lower Aratauran beds from New Zealand yielding a very similar *Palmoxytoma* species (Trechmann 1923 ; Arkell 1956 ; Damborenea & Manceñido, 1992). Hettangian faunas are better known in Northeastern Russia, where the *Otapiria originalis* Zone spans all the stage and can be divided into beds with "*Pseudomytiloides*" *sinuosus* and beds with *Meleagrinella subolifex* (Polubotko & Repin 1988).

OTAPIRIA PACIFICA ASSEMBLAGE ZONE (Damborenea in Riccardi *et al.* 1990a).

In Argentina this zone ranges from the upper part of the Badouxia canadensis to the Agassiceras Ammonite Zones. It appears to be more or less coeval with the eastern *Otapiria omolonica* beds of Russia, regarded by some authors as the lower part of the Otapiria limaeformis Zone (Polubotko & Repin 1988 ; Sey & Kalacheva 1988). *Otapiria pacifica* COVACEVICH & ESCOBAR (1979 ; see also Damborenea 1992) is very similar to or may be even conspecific with, *O. limaeformis* (ZAKHAROV), but is quite different from approximately coeval *O. marshalli* Trechmann from New Zealand, yet somewhat reminiscent of early Aratauran forms usually identified as *O. marshalli* (see Damborenea & Manceñido, 1992).

CARDINIA CF. *LISTERI* FAUNULE

Between the Otapiria pacifica and O. neuquensis Assemblage Zones, near-shore bivalve faunas from the Andes are characterized by *Cardinia* cf. *listeri* (SOWERBY ; see figures in Damborenea, 1992 ; Riccardi *et al.* 1991). This relatively rich late Sinemurian faunule marks the appearance of several long-ranging species, such as *Weyla alata* (VON BUCH), *Entolium* cf. *lunare* (ROMER), *Chlamys textoria* (SCHLOTHEIM). It is equivalent to the O. limaeformis Zone (s.s.) from northern Russia, probably also to beds containing *Otapiria tailleuri* IMLAY (1967) in Alaska and to beds with *Posidonotis* spp. in western Canada and USA (Crickmay 1928 ; Palfy *et al.* 1990). A *Parainoceramus-Teinonuculana* Assemblage is recognized in Guangdong, China, for the same interval (Wang 1988).

OTAPIRIA NEUQUENSIS ASSEMBLAGE ZONE (Damborenea *in* Riccardi *et al.* 1990a).

This zone is well-characterized and has a wide geographical distribution in Argentina, ranging from the upper part of the *Miltoceras* faunule to the lower part of the Fanninoceras Ammonite Zone (lower Pliensbachian). Within this diverse bivalve fauna, new species of *Kolymonectes* and *Kalentera* are useful to establish comparisons with other regions. In northeast Russia Early Pliensbachian times are characterized by the Chlamys tapensis Zone (Polubotko & Repin 1988), which also contains *Kolymonectes staeschei* (POLUBOTKO), a species very akin to the Andean *Kolymonectes* (Damborenea 1991, 1993). On the other hand *Kalentera* n. sp. from this assemblage is very close to *K. mackayi* MARWICK from upper Aratauran beds of New Zealand (see Damborenea, 1992 ; Damborenea & Manceñido, 1992). *Otapiria neuquensis* DAMBORENEA (1987) resembles both *O. tailleuri* IMLAY from Alaska and *Lu-*

pherella boechiformis (HYATT) from western North America (Imlay 1967), but the northern species seem to be slightly older and younger respectively. Similarly, *Otapiria* cf. *limaeformis* and *Kolymonectes staeschei* have just been recorded from northwestern Canada (Poulton 1991).

RADULONECTITES SOSNEADOENSIS ASSEMBLAGE ZONE (Damborenea *in* Riccardi *et al.* 1990a).

This zone covers the remaining part of the *Fanninoceras* Ammonite Zone (latest Lower and most of Upper Pliensbachian) and is widespread in Argentina and Chile. The species *R. sosneadoensis* has been figured by Weaver (1931) and Damborenea (1991, 1992, 1993). This assemblage zone is roughly equivalent to the *Eopecten viligaensis* plus the *Radulonectites hayamii* Zones of eastern Rusia (Polubotko & Repin 1988) and the *R. japonicus* beds of Japan (Hayami 1975, 1985). At least part of the Pliensbachian material illustrated by Poulton (1991) as *Camptonectes (Camptochlamys)* sp. apparently belongs to *Radulonectites*. In certain Andean facies, the pectinid *"Camptochlamys" wunschae* (MARWICK) and *Plicatula (Harpax) rapa* BAYLE & COQUAND occur also in this assemblage (Damborenea 1991, 1992). These two species are conspicuous elements in the lower Ururoan of New Zealand (Marwick 1953 ; Damborenea, 1993 ; Damborenea & Manceñido, 1992), which is characterized by the endemic *Pseudaucella marshalli* MARWICK. *Plicatula (H.) rapa* belongs to the same group as the *H.* ex gr. *spinosus* (SOW.) in Polubotko (1968) and Sey (1984) from coeval beds of Russia (see discussion in Damborenea, 1993).

POSIDONOTIS CANCELLATA ASSEMBLAGE ZONE (Damborenea *in* Riccardi *et al.* 1990a).

This zone spans the D. simplex and the D. tenuicostatum chilense Ammonite Zones and has also a wide distribution in Argentina and Chile. It can be correlated with the *Posidonotis* beds of Japan (Hayami 1985) and with the lower part of *Meleagrinella substriata* beds of northern Russia. Lower Ururoan beds with *Parainoceramus martini* from New Zealand appear to be roughly equivalent too. In South America *Posidonotis* consistently appears at the Pliensbachian-Toarcian boundary, but beds with *Posidonotis* sp. in western North America seem to be significantly older (Damborenea 1989 ; Palfy *et al.* 1990).

PROPEAMUSSIUM PUMILUM ASSEMBLAGE ZONE (Damborenea *in* Riccardi *et al.* 1990a).

This zone extends over most of the Toarcian and is roughly equivalent to *Meleagrinella substriata* and *M. faminaestriata* beds of northern Russia, to the beds with *"Inoceramus" ururoaensis* SPEDEN of New Zealand and probably to those with *Parainoceramus matsumotoi* HAYAMI (1960) of Japan, too.

MELEAGRINELLA FAUNULE.

Uppermost Toarcian and Aalenian beds in western Argentina contain a relatively diverse nearshore bivalve assemblage with *Melagrinella* sp. Off-shore bivalve faunas are still imperfectly known but may allow in the future the recognition of more than one biostratigraphical unit for this interval. Lower Aalenian beds of Russia contain *Arctotis marchaensis* (KRYMGOLTS) and in the Andes the species *A.* ? *frenguellii* (DAMBORENEA) is probably of the same age. In eastern Russia the first species of *Retroceramus* (or *Mytiloceramus* according to some authors) allow the recognition of the "M." priscus, "M." popovi and "M." obliquus Zones (see Sey & Kalacheva 1980, 1988 ; Polubotko & Repin 1988). In New Zealand the appearance of *Meleagrinella* has been used to mark the base of the Temaikan local stage (Marwick 1953). However, Hudson (1983) regards that usage as unsuitable because the distribution of these fossils is too dependent on facies control. Nevertheless, in a broad sense, the lowermost Temaikan beds of New Zealand (see Damborenea & Manceñido, 1992) and the *Inoceramus* ? *kudoi* HAYAMI (1960) beds of Japan are probably coeval with the *Meleagrinella* faunule of the Andes.

PROPEAMUSSIUM ANDIUM ASSEMBLAGE ZONE (new herein).

A peak in diversity for the whole Middle Jurassic of the Andes occurs between the Singularis and lower part of the Humphriesianum Standard Zones (Riccardi *et al.*, in press). A new bivalve assemblage zone in here proposed, characterized by *Propeamussium andium* (TORNQUIST, see figures in Damborenea, 1992 ; Damborenea & Manceñido, 1992). This zone has a very wide geographical distribution in Argentina from San Juan to Neuquén provinces. It can be correlated with the *"M." jurensis* and the *"M." menneri* beds of eastern Russia (Sey & Kalacheva 1980, 1988 ; Polubotko & Repin 1988), the *R. morii* (HAYAMI) beds of Japan (Hayami 1960), and the *Camptonectes lens - Liostrea birmanica* beds of China (Wang 1988). Also roughly equivalent are New Zealand lower Temaikan with *Propeamussium clamosseum* MARWICK, beds with *P. geelvinki* SKWARKO (1974)

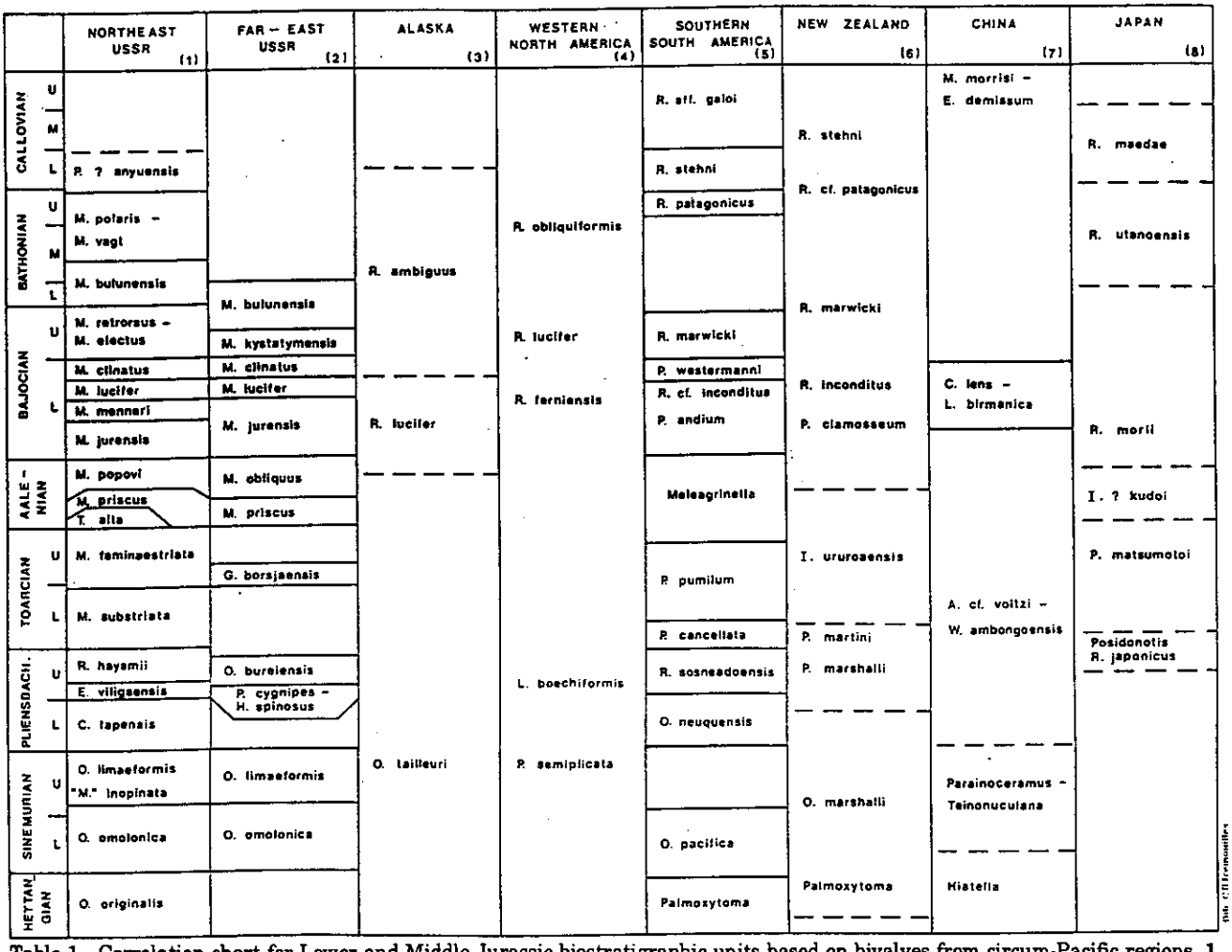

Table 1 - Correlation chart for Lower and Middle Jurassic biostratigraphic units based on bivalves from circum-Pacific regions. **1**, Polubotko & Sey 1981 ; Polubotko & Repin 1988 ; Zakharov *et al.* 1988 ; Sey *et al.* in Damborenea *et al.*, 1992. **2**, Polubotko & Sey 1981 ; Sey 1984 ; Sey & Kalacheva 1980 ; 1985 ; 1988 ; Sey *et al.* in Damborenea *et al.*, 1992. **3**, Imlay & Detterman 1973. **4**, Frebold 1964 ; Imlay 1967 ; Palfy *et al.* 1990. **5**, Damborenea 1990 ; Riccardi *et al.* 1990a herein. **6**, Fleming & Kear 1960 ; Marwick 1953 ; Speden 1970 ; Stevens 1978 ; Stevens & Speden 1978 ; Damborenea & Manceñido, 1992. **7**, Wang & Sun 1983 ; Wang 1988. **8**, Hayami 1960, 1985. *Cadre de corrélation des unités biostratigraphiques de bivalves du Jurassique inférieur et moyen des régions circum-pacifiques.*

from western Australia and perhaps beds with *R. lucifer* (EICHWALD) from Alaska.

The upper part of the P. andium Zone may be distinguished as a different unit, characterized by *Retroceramus* cf. *inconditus* (MARWICK) (figured as *R.*? sp. in Damborenea 1990). This occurrence is, thus far, only known from the Giebeli Zone of southern Mendoza province and is probably coeval ith the lower Temaikan beds of New Zealand with *R. inconditus* (Marwick 1953, Speden 1970). This species belongs to the group of *R. popovi* (KOSHELKINA) which in northern Rusia occurs in the topmost Aalenian (Koshelkina 1962 ; Sey & Polubotko 1976). In Boreal regions the Sauzei Standard Zone interval is represented by the highly distinct and widespread *Retroceramus lucifer* Zone (Imlay 1955 ; Sey & Kalacheva 1980, 1988 ; Polubotko & Sey 1981 ; Polubotko & Repin 1988).

PARAINOCERAMUS? WESTERMANNI ASSEMBLAGE ZONE (new status, as *P.*? *westermanni* beds in Damborenea 1990).

This unit is here formally raised to assemblage zone. *Parainoceramus*? *westermanni* DAMBORENEA is known from its type locality in Chacay Melehue and from other regions in central Neuquén. The assemblage ranges through most of the Humphriesianum Standard Zone, in Argentina, and includes also "*Astarte*" *puelmae* STEINMANN in near-shore facies and other bivalves which persist from older beds. It is probably equivalent to the uppermost Lower Bajocian "*M.*" *clinatus* Zone of Russia (Sey & Kalacheva 1980, 1988 ; Polubo-

tko & Repin 1988). *Retroceramus brownei* MARWICK (1953) from New Zealand occupies a similar stratigraphic position, though it is very difficult to date accurately. *Retroceramus ferniensis* (WARREN) occurs below *R. lucifer* (Frebold 1964) at about the Lower-Upper Bajocian boundary.

RETROCERAMUS MARWICKI ASSEMBLAGE ZONE (new status, as *R.* cf. *marwicki* beds in Damborenea 1990).

This zone spans the uppermost Humphriesianum and the Rotundum Zones (upper Bajocian) and contains *Retroceramus marwicki* SPEDEN. This species belongs to the *R. lucifer* (EICHWALD) group *sensu* Hayami (1960), which is known in Boreal regions in somewhat older (Lower Bajocian) beds (Imlay 1955 ; Polubotko 1968). The assemblage is typically developed in the Chacay Melehue section of northern Neuquén province, where it is accurately dated by ammonites (see Damborenea 1990). It can be correlated to the "*M.*" *kystatymensis* beds of Far East Russia (Sey & Kalacheva 1980, 1988) and the lower part of the "M." retrorsus - "M." electus Zone of eastern Siberia (Polubotko & Repin 1988). In New Zealand the *R. marwicki* beds are well-known and widespread and have been referred to the Callovian, or Bathonian-Callovian, on preliminary ammonite identifications (Stevens & Speden 1978). Nevertheless, the Bajocian age of the material from the Andes suggests the need to adjust the dating of the *marwicki*-bearing Temaikan in New Zealand. It is interesting to note that New Zealand material previously assigned to "*Kamptokephalites*" (thus late Bathonian-early Callovian) is currently being reinterpreted as a new sphaeroceratid of "mid" Bajocian age (G. Westermann, pers. commun., 1992).

In western North America *R. lucifer* appears to be somewhat younger than in other Boreal regions (Frebold 1964) and its appearance in the "*Arkelloceras* Bed" can be correlated with the R. marwicki Ass. Zone.

LOWER AND MIDDLE BATHONIAN

No bivalves are recorded from this age in Argentina, but in eastern Russia the "M." bulunensis Zone is characterized by very large inoceramids (Sey & Kalacheva 1980, 1988 ; Polubotko & Repin 1988). *Retroceramus ambiguus* (EICHWALD) may represent this interval in Alaska (Imlay & Detterman 1973) and *R. utanoensis* (KOBAYASHI) in Japan (Hayami 1960).

RETROCERAMUS PATAGONICUS ASSEMBLAGE ZONE (new status, as *R. patagonicus* beds in Damborenea 1990).

This zone occurs in the upper Bathonian and is equivalent to most of the Steinmanni Standard Zone. *Retroceramus patagonicus* (PHILIPPI) is ornamented by regularly spaced, narrow concentric folds separated by intervals up to twice as wide. The presence of *R.* cf. *patagonicus* in New Zealand (see Damborenea & Manceñido, 1992) is vital to the question of the Temaikan-Heterian boundary (and accurate correlations among southern regions) since it partially fills an apparent time gap in the local sequence. Westermann & Hudson (1991) described some of the accompanying ammonites. Part of the "M." polaris - "M." vagt Zone of northern Russia and the beds with *R. obliquiformis* (MCLEARN) from western North America (Frebold 1964) may be correlated with this Assemblage Zone.

RETROCERAMUS STEHNI ASSEMBLAGE ZONE (new status, as *R. stehni* beds in Damborenea 1990).

This zone ranges in age from latest Bathonian (uppermost *E. gerthi* Ammonite Horizon) to early Callovian (lower Bodenbenderi Standard Zone) and is present in several localities of western Argentina and Chile. *Retroceramus stehni* DAMBORENEA has large shells ornamented by sharp concentric folds which dorsally become low or disappear. It belongs to the *R. retrorsus* (KEYSERLING) group but this has a much more irregular distribution of concentric folds (Polubotko 1968). The most similar species from Boreal regions are "*M.*" *bulunensis* (KOSHELKINA) and *R. borealis* (KOSHELKINA), which are somewhat older (lower-middle Bathonian) according to Polubotko (1968) and Sey & Polubotko (1976).

Retroceramus stehni has also been found in New Zealand (Damborenea & Manceñido, 1992) and, together with *R.* cf. *patagonicus*, fills the Temaikan-Heterian gap.

This Assemblage Zone is approximately equivalent to the *Praebuchia* ? *anyuensis* beds of northern Russia (see Zakharov *et al.* 1988 for discussion of the probable age of this Boreal unit) and to the *R. maedae* (HAYAMI) beds of Japan (Hayami 1960).

MIDDLE - UPPER CALLOVIAN FAUNAS.

Retroceramus aff. *galoi* (BOEHM) was recently identified from Middle (?) Callovian beds of the Neuquén Basin (Damborenea 1990). No bivalve-bearing beds from this age have been reported from eastern Russia. A *Mesosaccella morrisi - En-*

tolium demissum Association is found in upper Callovian - Oxfordian beds of Heilongjiang, China (Wang 1988).

CONCLUDING REMARKS

- During the Early and Middle Jurassic, northern and southern Pacific bivalve faunas show broadly comparable successions of bivalve assemblages through time.

- Many South American assemblages consistently seem to be somewhat younger than their Boreal counterparts. This averages about half a Stage and such displacement in time may reflect progressive migration from north to south of some of the bivalve groups involved, but other causes should also be considered.

- In circum-Pacific regions direct correlation between bivalve biostratigraphic units is possible, especially between relatively close regions when the same bivalve groups are present.

- Knowledge obtained from Andean faunas can be applied to reconsider the age assignments of units recognized in other south Pacific regions, such as New Zealand local stages, which are mostly based on bivalves.

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