Vol. 78 No. 6 ACTA GEOLOGICA SINICA Dec. 2004 1179–1184
http://www.geojournals.cn/dzxbcn/ch/index.aspx

Early Permian Conodonts from the Baoshan Block, Western Yunnan, China

JI Zhansheng[1], YAO Jianxin[1], JIN Xiaochi[1],
YANG Xiangning[2], WANG Yizhao[3], YANG Hailin[2] and WU Guichun[1]
1 *Institute of Geology, Chinese Academy of Geological Sciences, 26 Baiwangzhuang Road, Beijing 100037; E-mail: jizhansheng@vip.sina.com*
2 *Department of Earth Sciences, Nanjing University, Nanjing, Jiangsu 210093*
3 *Geological Survey of Yunnan, Yujiang Road, Yuxi, Yunnan 653100*

Abstract The *Rabeignathus bucaramangus* fauna was recently found from the limestone beds of the top part of the clastics-dominated Dingjiazhai Formation in the Aluotian section, southern Baoshan Block, western Yunnan. With *Rabeignathus bucaramangus* as the dominant species, this fauna includes *Rabeignathus bucaramangus* (Rabe), *Homeoiranognathus huecoensis* (Ritter), *Sweetognathus inornatus* Ritter, *Sweetognathus whitei* (Rhodes), *Mesogondolella* cf. *bisselli* (Clark and Behnken) and a few of ramiform elements. The characteristics of the fauna suggest that it can be correlated with the upper part of the *Sweetognathus whitei* Zone and assigned to the Middle Artinskian.

Key words: *Rabeignathus*, Baoshan, Yunnan, Artinskian, Permian, conodont

1 Introduction

The Baoshan Block in western Yunnan, China is bounded on the east by the Langcangjiang Fault and the Nandinghe Fault, and on the west by the Nujiang Fault (Jin, 1994) (Fig. 1). The Dingjiazhai Formation on this block, which is composed primarily of clastic sediments and contains Gondwana-affinity fossils, is interpreted by many authors as of glacio-marine origin (e.g. Jin, 1994, 1996, 2002; Shi et al. 1996; Wang et al., 2001).

The Dingjiazhai Formation was mapped as an Upper Carboniferous formation (Geological Survey of Yunnan, 1980), because some fusulinid fossils from the limestones of the top part of this formation were identified as *Triticites* and the Carboniferous\Permian boundary in China was put on the top of the Mapingian stage (top of the fusulind *Pseudoschwagerina* s.l. zone) at that time. This age assignment was followed later also by some other authors (Chen, 1984; Cao, 1986; Fang and Fan, 1994). Nie et al. (1993) assigned the Dingjiazhai Foramtion to the Early Permian, based on the brachiopod *Stereochia litostyla* Grant and interpreted the *Triticites* fossils as reworked grains. Fang et al. (2000) negated the re-deposition interpretation, and considered that the Dingjiazhai Formation has an Asselian to Sakmarian age. Shi et al. (1996) and Shen et al. (2000) suggested that the age of the limestone in the upper Dingjiazhai Formation was probably late Sakmarian to Artinskian based on studies of brachiopods. After re-examination of the fusulinid fossils, Sugiyama and Ueno (1998), Wang et al. (1999, 2000, 2001) and Ueno (2000) proposed an Early Permian age for the upper part of Dingjiazhai Formation. Gao (1998) reported the *Parasaccites distinctus-Microbaculispora fentula* palynologic assemblage from the middle part of the Dingjiazhai Formation and assigned the formation to Asselian to Sarkmarian.

The finding of conodont fossils from the Dingjiazhai Formation provided another means of determining the age of this formation. Wang et al. (2000) and Ueno et al. (2002) described conodonts from the limestones of the top part of the Dingjiazhai Formation from the Dongshanpo and Dingjiazhai sections, and assigned the upper part of the Dingjiazhai Formation to the middle Artinskian corresponding to the upper part of the *Sweetognathus whitei-Mesogondolella bisselli* Zone. However, the fusulinids from the top part of the Dingjiazhai Formation indicate probably a late Sarkmarian age in the traditional view of fusulinoidean biochronology (Ueno et al., 2002).

Recently, we conducted a detailed fieldwork in western Yunnan and obtained quite a number of conodont specimens from the top part of the Dinjiazhai Formation in the Aluotian area and the Dingjiazhai area (Fig. 1). Here in this paper, we will describe the composition of the *Rabeignathus bucaramangus* fauna from the Aluotian section and make a further discussion on the age of the Dingjiazhai Formation.

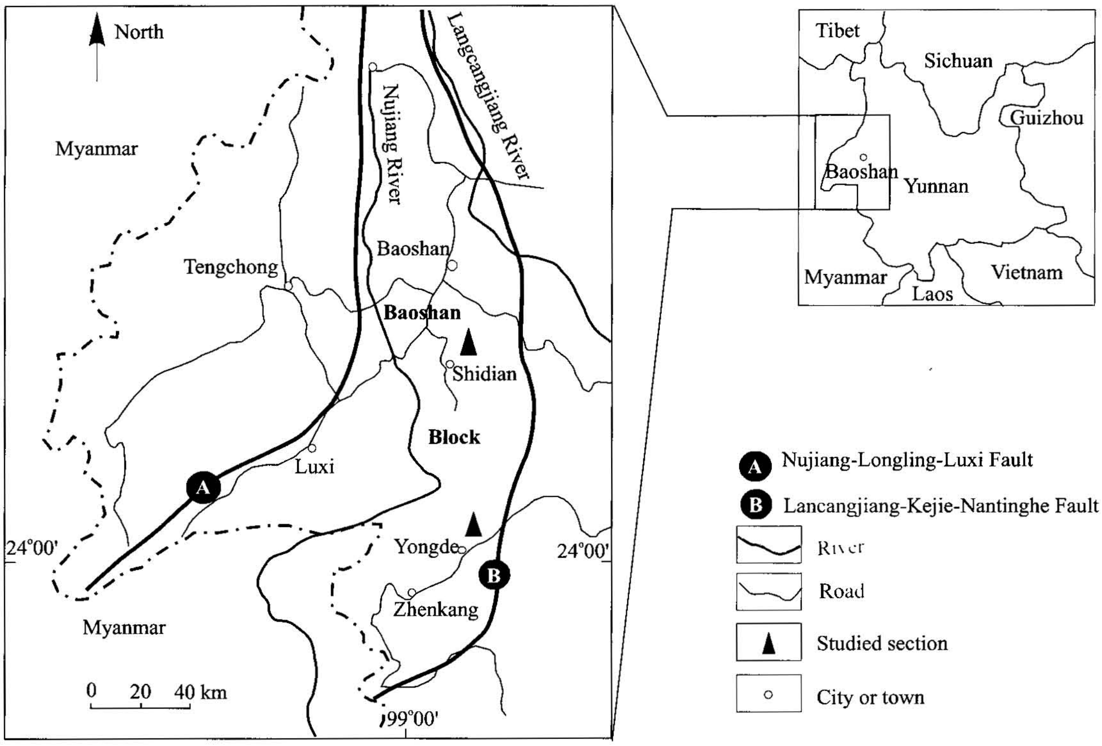

Fig. 1. Sketch map showing localities of studied sections.

2 Section and Samples

The Aluotian section is located to the north of Aluotian village, Yongde County, western Yunnan. The lithology of the Dingjiazhai Formation here is similar to that of the Dingjiazhai section, which is the type section of this formation. The lower part of the formation is composed of mudstone, diamictite and pebbly mudstone. The middle part comprises mudstone, sandstone and a few pebbly mudstones, containing brachiopods, bryozoans and crinoids. The top part, with a thickness of about 10 m, is composed of medium-thin bedded limestones, containing fusulinids and conodonts. There are several beds of lateritic sediments on the top of the limestones. These are then overlain by basalts of the Woniusi Formation.

Eighteen samples, each weighing 2–3 kg, were collected from the limestone unit in the top part of the Dingjiazhai Formation (Fig. 2). All samples were processed, however, conodonts were obtained only from three samples (i.e. Alt2, Alt3, and Alt4) from the bottom of the limestone unit within 3 meters. Specimens of *Rabeignathus bucaramangus* are concentrated in sample Alt2.

3 Fauna Contents and Correlation

The conodont fauna in the Aluotian section comprises *Rabeignathus bucaramangus* (Rabe), *Sweetognathus inornathus* Ritter, *S. whitei* (Rhodes), *Mesogondolella* cf. *bisselli* (Clark and Behnken), *Homeoiranognathus huecoensis* (Ritter) and a few of ramiform elements. The dominant species of the fauna is *Rabeignathus bucaramangus*. The *Mesogondolella* cf. *bisselli* from the present fauna (pl. 1, fig. 18) is almost the same as the *M. bisselli* illustrated by Ritter (1986, pl. 1, fig. 1; 1987, pl. 23.1, fig. 7) except that the robust and retroverted cusp is broken and the anterior part is lost in our specimen. Orchard et al. (1988) illustrated similar specimens (Pl. 3-15, 16), but identified them as *Neogondolella intermedia* Igo. The present specimen is also similar to the specimen identified as suspected *Neogondolella bisselli* (Clark and Behnken) by Orchard et al. (1988, pl. 3, fig. 14).

Similar faunas have been reported hitherto from four localities. Rabe (1977) reported a fauna from the eastern slope of Cordillera Central, north of Bucaramanga, Colombia. Ritter (1986, 1987) illustrated a similar conodont fauna including *R. bucaramangus* from Utah and Kansas, U.S.A. Reimers (1991, 1999) reported the *R. bucaramangus* fauna from the lower part of the Kotchusuy Suite in the Southeast Pamirs.

Reimers (1999) described two new species, namely *Rabeignathus mononodosus* and *R. binodosus*, from the Southeast Pamirs, where they coexists with *R. bucaramangus*. These two species are characterized by having respectively only one and two accessory nodes on

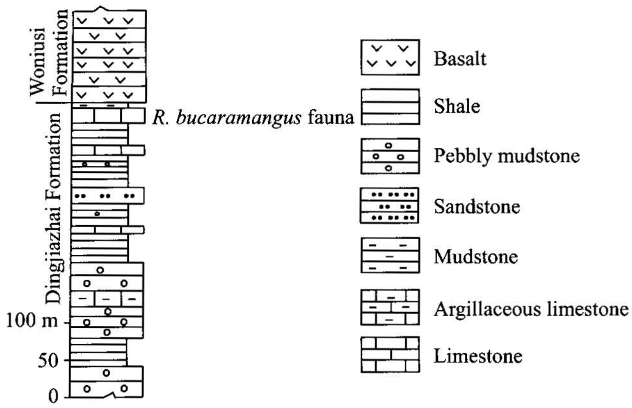

Fig. 2. Stratigraphic column of the Dingjiazhai Formation of the Aluotian section.

lateral platforms. Ueno et al. (2002) suggested that the number of accessory nodes is a variable morphological feature, and is, therefore, not a good criterion for species discrimination. We think that Ueno et al.'s opinion about the variance of accessory nodes is reasonable, and therefore classified our specimens with only one accessory node to *Rabeignathus bucaramangus*.

In the Baoshan Block, Ueno et al. (2002) illustrated specimens that have simple configuration of accessory nodes on the cup. They concluded, these morphological features could indicate that the Pa. elements of *R. bucaramengus* from the Baoshan Block are more primitive representatives of this species. Accordingly, they suggested that the conodonts might occur slightly earlier than the typical *R. bucaramangus* fauna. The present conodont fauna with typical *R. bucaramangus* may be correlated with the *R. bucaramangus* faunas previously reported.

4 Age of the *Rabeignathus bucaramangus* Fauna

Rabe (1977) assigned the *Rabeignathus bucaramangus* fauna to the late Wolfcampian and pointed out that it came from the horozons corresponding to the upper range of *Gnathus* aff. *whitei* (Rhodes). Ueno et al. (2002) reinterpreted the specimens illustrated as *G* . aff. *whitei* by Rabe (1977, pl. 4, fig. 14, 15) to be *Neostreptognathodus pequopensis* Behnken.

Ritter (1986, 1987) showed that the distribution of *R. bucaramangus* was restricted within the upper part of the *Sweetognathus whitei* Zone and did not enter the overlying *Neostreptognathodus pequopensis* Zone. The age of the *Rabeignathus bucamangus* fauna is assigned to the upper part of the *Sweetognathus whitei* Zone.

Reimers (1991) assigned the fauna to the Bolorian (Kungurian). Ueno et al. (2002) reinterpreted the specimens illustrated as *Mesogondolella idahoensis* (Youngouist, Hawley et Miller) by Reimers (1991, pl. 1, fig. 15) to be *M. bisselli*, and a specimen illustrated as *N. sulcoplicatus* (Youngouist, Hawley et Miller) by Reimers (1991, pl. 1, fig. 5) to be possibly *N. exsculptus* Igo. Mei et al. (1999a) and Mei and Henderson (2001) demonstrated that the first occurrence of *N. exsculptus* is within the *N. pequopensis* Zone. Accordingly, Ueno et al. (2002) suggested that the conodont fauna, including *R. bucaramangus*, reported by Reimers (1991), is the middle Artinskian rather than the Bolorian because the *N. pequopensis* Zone is currently the uppermost zone of the Artinskian (Jin et al., 1997).

Kozur (1995) noted that the genus *Rabeignathus* is a distinct and globally distributed shallow-water conodont in the latest Artinskian and the early Cathedralian (Kungurian). Its upper range is in the lower Cathedralian *Mesogondolella intermedia-Neostreptognathodus exsculptus* Zone. Therefore, the range of *R. bucaramangus* fauna is from the upper part of the *Sweetognathus whitei* Zone to *Neostreptognathodus pequopensis* Zone.

According to the subdivision of the Permian proposed by Jin et al. (1997), the base of the Artinskian is defined by the first occurrence of *S. whitei* and the upper Artinskian is represented by the *N. pequopensis* Zone. The present conodont fauna from the Aluotian section contains *S. whitei*, but not *Neostreptognathodus pequopensis*, therefore, it should be assigned to the upper part of the *Sweetognathus whitei* Zone with a middle Artinskian age.

5 Discussion on the Difference between *Rabeignathus* and *Sweetognathus*

Based on *Spathognathodus whitei* Rhodes, 1963, Clark (1972) established the genus *Sweetognathus*. The diagnostic features of the genus are apparatus probably unimembrate; pectiniform element scaphate with short free anterior blade in young forms; blade approaching the length of the total unit in older forms; and faint rostrum in juveniles, developing to rostrum and carina at maturity. According to the existence of accessory nodes on the cup, Kozur (1978) introduced the genus *Rabeignathus*, taking *Gnathodus bucaramangus* Rabe, 1977 as the type species. Sweet (1988) and Mei et al. (1999b) regarded *Rabeignathus* as *Sweetognathus* with accessory nodes. Ueno et al. (2002) followed this understanding. However, Kozur (per. com.) thinks that the differences between *Rabeignathus* and *Sweetognathus* are the same as that between *Hindeodus* (without nodes on the cup) and *Isarcicella* (with nodes on the cup) of the Early Triassic. He suggests that *Sweetognathus* comprises the forms without nodes on the cup and with nodes on the carina, and has an age range from the Sakmarian to the early Capitanian; *Rabeignathus* includes the forms with nodes on both the cup and the carina, and has an age range from the late Artinskian to Kungurian, even to Guadalupian.

We basically agree with Kozur's opinion. *Rabeignathus* is different from *Sweetognathus* in terms of the height and shape of the cup, and the existence of accessory nodes. Furthermore, the configurations of accessory nodes in *Rabeignathus* display various patterns. Therefore, *Rabeignathus* is used as a valid genus in this paper. From this point of view, *Sweetognathus fengshanensis* from Laibin of Guangxi, China (Mei et al., 1998, plate 2, fig. 6; plate 3, figs. 5–9) should also be considered as a species of the Genus *Rabeignathus*.

6 Conclusions

The conodont fauna from the Aluotian section, western Yunnan can well be correlated with those from the north of Bucaramanga, Colombia (Rabe, 1977), Southeast Pamirs (Reimers, 1991, 1999), Utah and Kansas, U.S.A. (Ritter, 1986, 1987).

The stratigraphic position of the present fauna is equivalent to the upper *Sweetognathus whitei* Zone, and has an age of the middle Artinskian.

Ackowledgements

This work is supported by the National Natural Science Foundation of China (Grant No. 40232024) and Chinese Geological Survey (Grant No. 200313000054). We thank Heinz Kozur for some suggestions, and Wang Naiwen for translating some Russian literature.

Manuscript received June 28, 2004
accepted Oct. 8, 2004
edited by Xie Guanglian

References

Cao Renguan, 1986. Discovery of Late Carboniferous glacial-marine deposits in Western Yunnan. *Geol. Rev.*, 32: 236–242 (in Chinese with English abstract).

Chen Genbao, 1984. The Carboniferous of the Baoshan area, western Yunnan. *Journal of Stratigraphy*, 8: 129–135 (in Chinese with English abstract).

Clark, D.L., 1972. Early Permian crisis and its bearing on Permo-Triassic conodont taxonomy. In: Lindström, M., and Ziegler, W. (eds.), *Symposium on Conodont Taxonomy*. Geologica et Palaeontologica SB, 1, 147–158.

Fang Runsen and Fan Jiancai, 1994. *Middle to Upper Carboniferous-Early Permian Gondwana Facies and Palaeontology in Western Yunnan, Yunnan*. Kunming: Science and Technology Press, 121 (in Chinese with English abstract).

Fang Zongjie, Wang Yujing, Shi Guang Rong, Zhou Zhicheng and Xiao Yinwen, 2000. On the age of the Dingjiazhai Formation of Baoshan Block, western Yunnan, China—with a discussion on the redeposition hypothesis. *Acta Palaeontologica Sinica*, 39: 267–278 (in Chinese with English abstract).

Gao Lianda, 1998. On the discovery of a Gondwana affinity microflora from Baoshan, West Yunnan and its Geologic Significance. *Acta Geosci. Sinica*, 19(1): 105–112 (in Chinese with English abstract).

Jin Xiaochi, 1994. Sedimentary and palaeogeographic significance of Permo-Carboniferous sequences in western Yunnan, China. *Geologisches Institut der Universität zu Köln Sonderveröffentlichungen*, 99: 1–136.

Jin Xiaochi, 1996. Tectono-stratigraphic units in western Yunnan and their counterparts in Southeast Asia. *Continental Dynamics*, 1(2): 123–133.

Jin Xiaochi, 2002. Permo-Carboniferous depositional sequences of Gondwana affinity in southwest China and their paleogeographic implications. *J. Asian Earth Sci.*, 20(6): 633–646.

Jin Yugan, Wardlaw, B.R., Glenister, B.F., and Kotlyar, G.V., 1997. Permian chronostratigraphic subdivisions. *Episodes*, 20 (1): 10–15.

Kozur, H., 1978. Beiträge zur Stratigraphie des Perms. Teil II: *Die Conodontenchronologie des Perms*. Freiberger Forschungsheft, C 334: 85–161 (in German).

Kozur, H., 1995. Permian conodont zonation and its importance for the Permian stratigraphic standard scale. *Geologisch-Paläontologische Mitteilungen Innsbruck*, 20: 165–205.

Mei Shilong and Henderson, C.M., 2001. Evolution of Permian condont provincialism and its significance in global correlation and paleoclimate implication. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 170: 237–260.

Mei Shilong, Henderson, C.M., and Jin Yungan, 1999a. Permian conodont provincialism zonation and global correlation, *Permophiles*, 35: 9–16.

Mei Shilong, Henderson, C.M., and Wardlaw, B.R., 1999b. Evolution and distribution of *Sweetognathus* and *Iranognathus* and their related conodonts during the Permian and their implications to climate changes. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 180: 57–91.

Mei Shilong, Jin Yungan and Wardlaw, B.R., 1998. Conodont succession of the Guadalupian-Lopingian boundary strata in Laibin of Guangxi, China and West Texas, USA. *Palaeoworld*, 9: 53–76.

Nie Zetong, Song Zhimin, Jiang Jianjun and Liang Dingyi, 1993. Biota features of the Gondwana affinity facies and review of their stratigraphic ages in the western Yunnan. *Geoscience—Journal of Graduate School, China University of Geoscience*, 7: 384–393 (in Chinese with English abstract).

Orchard, M.J., and Forster, P.J.L., 1988. Permian conodont biostratigraphy of the Harper Ranch beds near Kamloops, south-central British Columbia. *Geological Survey of Canada Paper*, 88(8): 1–27.

Rabe, E.H., 1977. Zur Stratigraphie des ostandinen Raumes von Kolumbien. *Giessener Geologische Schriften*, 11: 101–223.

Geological Survey of Yunnan, 1980. *Geological Map of China*, the Baoshan sheet, 1:200,000 (in Chinese).

Reimers, A.N., 1991. Lower Permian Conodonts of Pamir and Darvaza. *Byulleten Moskovskogo Obschestva Ispytateley Prirody, otdel geologicheskiy*, 66: 59–72 (in Russian with English abstract).

Reimers, A.N., 1999. *Konodonty nizhney permi Urala, Prikaspiya I Pamira*. Izdatel'stvo GEOS, Moskva, 1–211 (in Russian).

Ritter, S.M., 1986. Taxonomic revision and phylogeny of post-Early Permian crisis *bisselli-whitei* Zone conodonts with comments on late Paleozoic diversity. *Geologica et*

Palaeontologica, 20: 139–165.

Ritter, S.M., 1987. Biofacies-based refinement of Early Permian conodont biostratigraphy, in central and western USA. In: Austin, R.L. (ed.), *Conodonts, Investigative Techniques and Applications*. British Micropalaeontological Society Series. Chichester: Ellis Horwood Limited Publisher, 382–403.

Shen Shuzhong, Shi, G.R., and Zhu Kuiyu, 2000. Early Permian brachiopods of Gondwana affinity from the Dingjiazhai Formation of the Baoshan Block, western Yunnan, China. *Rivista Italiana di Paleontologica e Stratigrafia*, 106: 263–282.

Shi, G.R., Fang Zongjie and Archbold, N.W., 1996. An Early Permian brachiopod fauna of Gondwana affinity from the Baoshan Block, western Yunnan, China. *Alcheringa*, 20: 81–101.

Sugiyama, T., and Ueno, K., 1998. Palaeobiogeography of Gondwana-derived terranes in western Yunnan, South China (preliminary report). *Journal of Geography*, 107: 549–558 (in Japanese).

Sweet, C.W., 1988. *The Conodonta-Morphology, Taxonomy, Paleoecology, and Evolutionary History of a Long-Extinct Animal Phylum*. Oxford: Clarendon Press, 45–128.

Ueno K., 2000. Permian fusulinacean faunas of the Sibumasu and Baoshan Blocks: implications for the paleogeographic reconstruction of the Cimmerian continent. *Geosciences Journal*, 4 (special edition): 160–163.

Ueno, K., Mizuno, Y., Wang Xiangdong and Mei Shilong, 2002. Artinskian conodonts from the Dingjiazhai Formation of the Baoshan Block, West Yunnan, Southwest China. *Journal of Paleontology*, 76(4): 741–750.

Wang Xiangdong, Sugiyama, T., Ueno, K., and Mizuno, Y., 1999. Peri-Gondwana sequences of Carboniferous and Permian age in the Baoshan Block, West Yunnan, Southwest China. In: Ratanasthien, B., and Rieb, S.L. (eds.), *Proceedings of the International Symposium on Shallow Tethys 5*, Chiang Mai, Thailand, 88–100.

Wang Xiangdong, Sugiyama, T., Ueno, K., Mizuno, Y., Li Yijun, Wang Wei, Duan Weixian and Yao Jincang, 2000. Carboniferous and Permian zoogeographical change of the Baoshan Block, Southwest China. *Acta Palaeontogica Sinica*, 39: 493–506 (in Chinese with English abstract).

Wang Xiangdong, Ueno, K., Mizuno, Y., and Sugiyama, T., 2001. Late Paleozoic faunal, climatic, and geographic changes in Baoshan Block as a Gondwana-derived continental fragment in Southwest China. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 170: 197–218.

Explanation of Plate

All specimens illustrated here are from the upper part of the Dingjiazhai Formation, Aluotian section. Pl. I-2–5, 8–17, 19–21 are from sample Alt2; Pl. I-18 from sample Alt3; and Pl. I-1, 6, 7, 22 from sample Alt4. Specimens are housed in the Institute of Geology, Chinese Academy of Geology Sciences.

1. *Sweetognathus inornatus* Ritter 1986
   Pa element, upper view, ×180, SEM No. 37174

2–5, 8, 11–17. *Rabeignathus burcaramangus* (Rabe, 1977)
   2. Pa element, upper view, ×120, SEM No. 60058
   3. Pa element, upper view, ×150, SEM No. 37163
   4. Pa element, upper view, ×120, SEM No. 60081
   5. Pa element, upper view, ×120, SEM No. 60053
   8. Pa element, upper view, ×100,SEM No. 37164
   11. Pa element, upper view, ×120, SEM No. 60077
   12. Pa element, half of posterior fragment, ×120, SEM No. 60067
   13. Pa element, anterior fragment, ×95, SEM No. 60060
   14. Pa element, upper views, ×95, SEM No.60072
   15. Pa element, posterior fragment, ×95, SEM No. 60064
   16. Pa element, posterior fragment, ×120, SEM No. 60054
   17. Pa element, upper view ×120, SEM No.60070

6, 7. *Sweetognathus whitei* (Rhodes, 1963)
   6. Pa element, upper view, ×180, SEM No. 37173
   7. Pa element, upper view, ×100, SEM No. 37171

9. *Homeoiranognathus huecoensis* (Ritter, 1986)
   Pa element, upper view, ×100, SEM No. 37165

10. *Rabeignathus* sp.
   Pa element, anterior fragment, ×150, SEM No. 37169

18. *Mesogondolella* cf. *bisselli* (Clark and Behnken, 1971)
   18 Pa element, oblique view, ×250, SEM No. 37179

19–22. *Sweetognathus* sp.
   19. S element, lateral view, ×95, SEM No. 60056
   20. Pa element, lateral view, ×120, SEM No. 60074
   21. S element, lateral view, ×95, SEM No. 60080
   22. Pa element, lateral view, ×130, SEM No. 37175

Plate I