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Mylagaulids (Mammalia: Rodentia) from the early Middle Miocene of northern Junggar Basin

WU Wen-Yu[1] NI Xi-Jun[1] YE Jie[1] MENG Jin[1,2] BI Shun-Dong[1,3]

(1 *Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences* Beijing 100044 wuwy242@hotmail.com)
(2 *American Museum of Natural History* New York NY 10024)
(3 *Department of Biology, Indiana University of Pennsylvania* Indiana PA 15705)

Abstract Application of CT (computed tomography) scanning technology to the study of tooth morphology of mylagaulids makes better understanding the tooth structure of high-crowned mylagaulids. Two genera and species from the early Middle Miocene Halamagai Formation in northern Junggar Basin of Xinjiang are recognized: *Tschalimys ckhikvadzei* Shevyreva, 1971, the senior synonym of *Sinomylagaulus halamagaiensis* Wu, 1988 and *Simpligaulus yangi* gen. et sp. nov. Both taxa undoubtedly belong to the subfamily Promylagaulinae. The integrated lithological, paleontological and paleomagnetic studies on sediments of the Late Oligocene through Late Miocene in the northern Junggar Basin of Xinjiang demonstrate that Halamagai Formation is fluvial-lacustrine sediments formed during the time coincident to the Mid-Miocene Climatic Optimum. *T. ckhikvadzei* and *S. yangi* probably inhabit the humid and warm regions with forests and densely vegetated thickets as the living mountain beaver *Aplodontia rufa* does. These mylagaulids are probably immigrants or the descendants of the immigrants from west North America.

Key words northern Junggar Basin, early Middle Miocene, Promylagaulinae, climate, immigrants

Based only on a single P4, Wu created in 1988 a new genus and species of promylagauline *Sinomylagaulus halamagaiensis*, which was discovered in 1982 from the early Middle Miocene Halamagai Formation located in Tieersihabahe of northern Junggar Basin. New material, including only two p4, was found exhilaratingly after nine years around the same locality—XJ 97007(46° 39.735′ N; 88° 30.224′ E). The present paper is a report on the study of the three teeth.

It is well known that most genera of mylagaulids possess high crowned and complex cheek teeth with numerous enamel bordered lakes of different depths and which vary in size and shape with wear. It is therefore difficult to make taxonomic determination and assess the relationship of small samples. McGrew (1941) first studied the mylagaulids (*Mylagaulodon*) teeth by grinding serial sections. By using the same method, Black and Wood (1956) studied

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the age-and individual-variation of the teeth of *Mesogaulus novellus* (reassigned to *Galbreathia* by Korth, 1999). However it is essential to have sufficient material for making serial sections, thus this method is not practical for the research based on very few samples. The recently wide application of computed tomography technology in the paleontology makes it possible that the sample can be observed in detail without destruction. Here we study the three mylagaulid teeth by using high-resolution CT scanning technique to virtually reconstruct their transverse section. CT scanning was performed by using ICT 225 kv high-resolution CT scanner in the Key Laboratory of Evolutionary Systematics of Vertebrates, Chinese Academy of Sciences. Three-dimensional reconstruction was conducted in VGStudios Max 2.0. Only the virtual transverse sections were examined. The section interval is 5 μ (4.987 μ). The terminology we used for description is after Rensberger (1979) with small modification (Fig. 1).

Two genera and species are recognized for the above mentioned material: *Tschalimys ckhikvadzei* Shevyreva, 1971 and *Simpligaulus yangi* gen. et sp. nov. Description on *S. yangi* and supplemental description on *T. ckhikvadzei* are provided in the present paper.

Rodentia Bowdich, 1821
Aplodontoidea Brandt, 1855
Mylagaulidae Cope, 1881
Promylagaulinae Rensberger, 1980
Tschalimys Shevyreva, 1971

Type species *Tschalimys ckhikvadzei* Shevyreva, 1971.

Diagnosis (amended) Small sized and hypsodont promylagauline. Occlusal surface of P4 longer than wide, with slightly lingually expanded anterocone, distinct parastyle and mesostyle; six deeply downwards extending fossettes present: antero- and posterolabial fossettes, antero-and posterolingual fossettes, labial-and lingual central fossettes; the anterolabial fossette and the anterolingual fossette connected anteriorly. With wear the connection between anterior fossettes disappears, and the lingual central fossette as well. The p4 with long, strong metastylid crest extending from metaconid to mesostylid, blocking lingual fossettid; mesostylid distinct; anterior-and posterior fossettids large; mesoconid flattened labially initially but becoming distinct with wear, forming Y-shaped labial inflection with stronger posterior branch (posterior labial inflection) than anterior one. Both P4 and p4 possessing open-ended single root.

Included species *Tschalimys ckhikvadzei* Shevyreva, 1971.

Geographic distribution and horizon Zaisan Basin of Kazakhstan, Sarybulak Formation; Tieersihabahe of northern Junggar Basin, Halamagai Formation.

Tschalimys ckhikvadzei Shevyreva, 1971

(Figs. 2-5)

Tschalimys ckhikvadzei Shevyreva, 1971, p.481-484, fig. 1

Sinomylagaulus halamagaiensis Wu, 1988, p. 251-253, 260-261, fig. 1

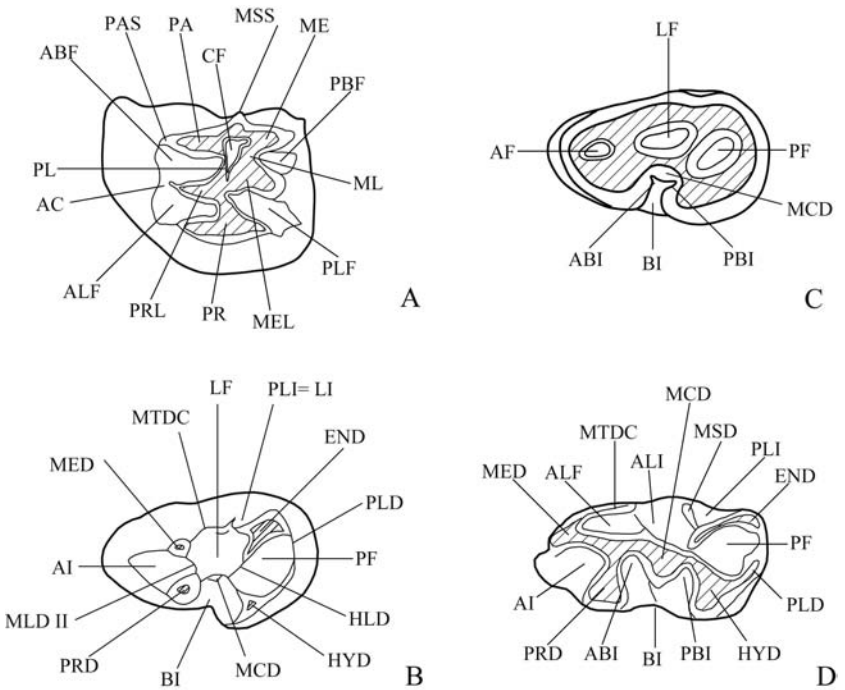

Fig. 1　Nomenclature of occlusal structure in Promylagaulinae

A. left P4; B. little worn left p4; C. well worn left p4; D. left dp4 (modified from Rensberger, 1979); cross hatching = dentine

Abbreviations: ABF. anterolabial fossette前唇侧凹; ABI. anterolabial inflection前唇侧湾; AC. anterocone前边尖; AF. anterior fossettid下前凹; AI. anterior inflection前湾; ALF. anterolingual fossette (-id)(下)前舌侧凹; ALI. anterolingual inflection下前舌侧湾; BI. labial inflection唇侧湾; CF. central fossette中凹; END. entoconid下内尖; HLD. hypolophid下次脊; HYD. hypoconid下次尖; LF. lingual fossettid下舌侧凹; LI (=PLI). lingual inflection下舌侧湾; MCD. mesoconid下中尖; ME. metacone后尖; MED. metaconid下后尖; MEL. metaconule后小尖; ML. metaloph后脊; MLD II. metalophulid II下后脊II; MSD. mesostylid下中附尖; MSS. mesostyle中附尖; MTDC. metastylid crest下后附尖脊; PA. paracone前尖; PAS. parastyle前附尖; PBF. posterolabial fossette后唇侧凹; PBI. posterolabial inflection后唇侧湾; PF. posterior fossettid下后凹; PL. protoloph原脊; PLD. posterolophid下后边脊; PLF. posterolingual fossette后舌侧凹; PLI. posterolingual inflection下后舌侧湾; PR. protocone原尖; PRD. protoconid下原尖; PRL. protoconule原小尖

Holotype　ПИН, No. 2977-3, right P4 (Shevyreva, 1971: 481-484, fig. 1).

Type locality　Zaisan Basin of Kazakhstan.

Age and horizon　Early Middle Miocene; Sarybulak Formation.

Diagnosis (amended)　Same as the genus.

Description　Two specimens are described: 1) right P4(IVPP V 8107) which was described in 1988, as holotype of *Sinomylagaulus halamagaiensis* Wu; 2) left p4(IVPP V 17928) were discovered in 1997. Both teeth came from around the locality XJ 97007(46°39.735′ N; 88°30.224′ E) of Tieersihabahe, northern Junggar Basin, in lower Halamagai Formation of early Middle Miocene.

Description of the virtual transverse sections of P4 (V 8107) Wu (1988) made detailed description of P4(V 8107). Here we provide description of virtual transverse sections of this tooth. Out of all 1409 virtual transverse sections, only 19 sections are illustrated to show the changes of the tooth morphology in transverse sections at various depth of the tooth (Fig. 2A-S). The distance of each CT section from the occlusal surface is as follows (in mm): A–0.80, B–0.87, C–1.01, D–1.08, E–1.115, F–1.185, G–1.255, H–1.36, I–1.43, J–1.71, K–2.025, L–2.55, M–3.04, N–3.565, O–3.95, P–4.44, Q–4.51, R–4.59, S–4.635. On Fig. 2A-C the image of the rear part of the tooth is incomplete because the occlusal surface is concave on this part. The parastyle and mesostyle become thinner towards tooth root: the parastyle does not disappear until in Fig. 2J (1.71 mm); the mesostyle is incomplete in Fig. 2A-G (0.80–1.255 mm), which was damaged while being moulded after the year of 1988, it regain intact in Fig. 2H (1.36 mm), and vanishes in Fig. 2M (3.04 mm). The antero-labial fossette and lingual fossette connect anteriorly in Fig. 2A-I (0.80–1.43 mm), and become separated from Fig. 2J (1.71 mm) on.

Both labial and lingual central fossettes are present in Fig. 2C-J (1.01–1.71 mm), gradually diminishing downwards, the lingual central fossette lost from Fig. 2K (2.025 mm) on, and the labial one disappears from Fig. 2M (3.04 mm) on. Both anterior- and posterior labial fossettes become disappear in Fig. 2O (3.95 mm). The anterior and posterior lingual fossette fades away respectively in Fig. 2R (4.59 mm) and Fig. 2Q (4.51 mm). The contour of the tooth also varies with wear.

Based on the comparison with known genera of mylagaulids, Wu considered (1988) V 8107 was most similar to *Tschalimys ckhikvadzei* from the Zaisan Basin of Kazakhstan but with some differences from the latter: P4 of V 8107 possesses a lingual central fossette in addition to the labial one, the anterior-labial and lingual fossettes are connected anteriorly instead of disconnected, the parastyle is not forked, the vertical axis of the tooth is curved, and the tooth is rooted. A new genus and species *Sinomylagaulus halamagaiensis* was therefore established for V 8107. However here presented serial CT sections demonstrate that the structure of V 8107, at the lower part of the tooth (Fig. 2K), is just like the holotype (ПИН, No. 2977-3) of *T. ckhikvadzei*: the anterior-labial and lingual fossettes are not connected, and the lingual central fossette is absent. It means that these structure differences of the occlusal surface between ПИН, No. 2977-3 and V 8107 in fact result from different stage of wear: V 8107 is less worn than ПИН, No. 2977-3. Shevyreva (1971) described that ПИН, No. 2977-3 has no root but according to her Fig. 1 the tooth should have root. Furthermore, the tooth axis of ПИН, No. 2977-3 is not straight as Wu noted (1988), whether the tooth axis is curve or straight can only be judged from the lateral side of the tooth but not from the labial side. The bifurcation of the parastyle of ПИН, No. 2977-3 can be considered as individual variation. However the parastyle extends until to one third tooth height, and the mesostyle ends close to the dentine tract, nearly the same situation as in V 8107. Furthermore, V 8107 is measured 3.89 mm (length) × 3.00 mm (width) × 5.5 2 mm (height) in size, matching well with *T. ckhikvadzei* which is measured 3.65–4.25 mm (length) × 3 mm

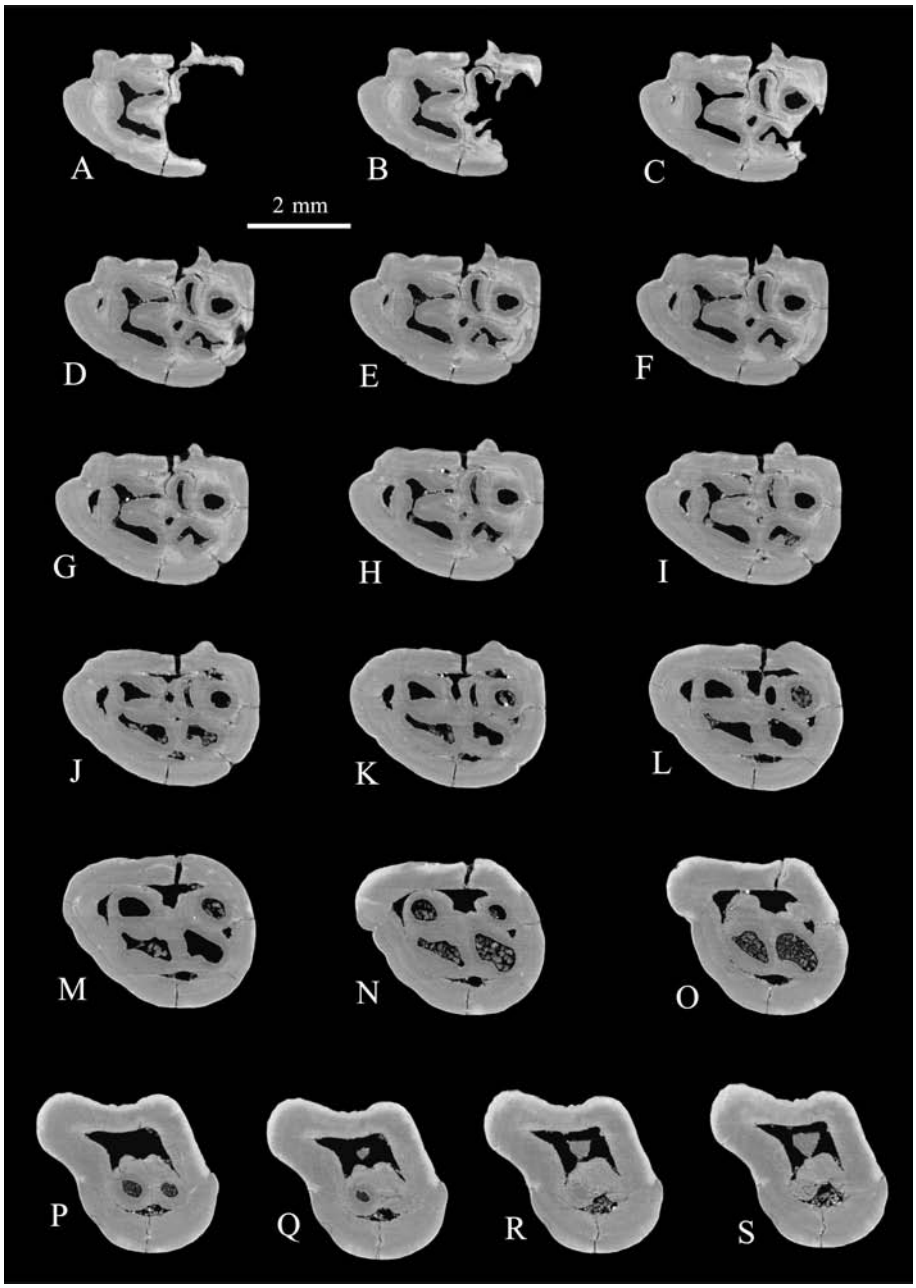

Fig. 2　Serial CT sections of P4 of *Tschalimys ckhikvadzei* (IVPP V 8107)

(width) × 6.4 mm (height). There were altogether 3 specimens of P4 for *T. ckhikvadzei* according to Shevyreva (1971), she must have provided the size range of these specimens but described only the holotype. From the above analysis we come to the conclusion that *S. halamagaiensis* should be the junior synonym of *T. ckhikvadzei*.

P4 (V 8107) lacks an appression facet for P3, as in *Promylagaulus riggsi* (Rensberger,

1979:11). Rensberger (1980) suggested that “the crown of P3 does not occlude with p4 during normal mastication”, which he considered as the character of Promylagaulinae.

Three-dimensional pictures of P4 (V 8107) are shown in Fig. 3.

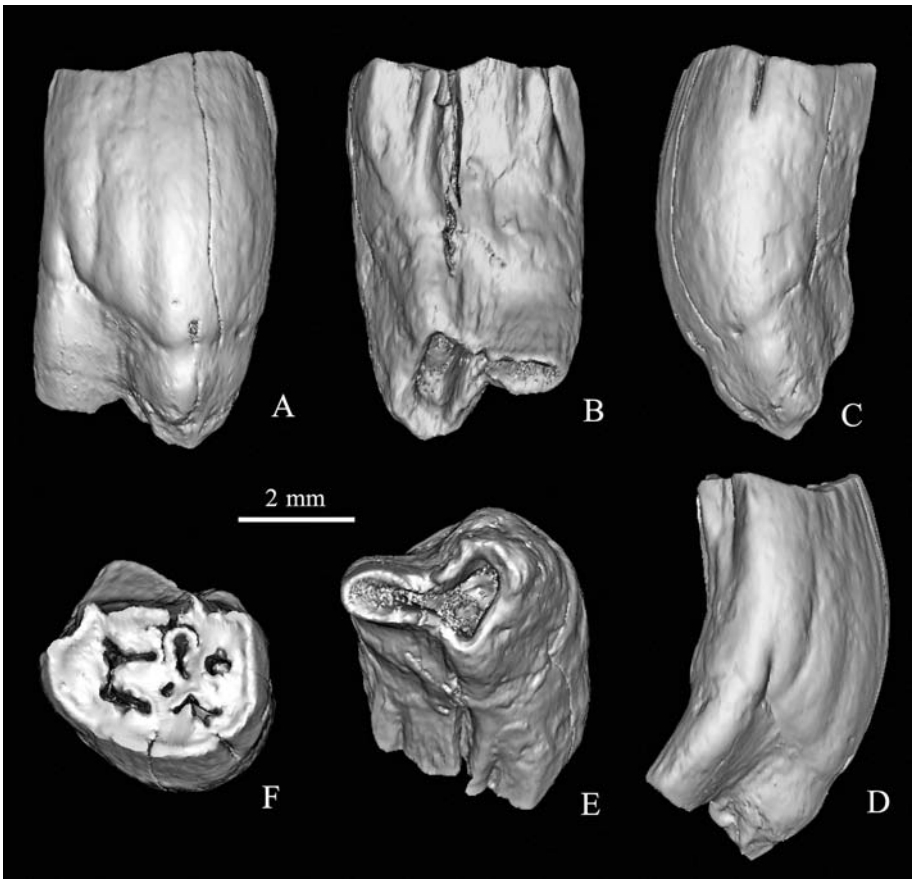

Fig. 3 Three-dimensional pictures (3d stereo images) of P4 of *Tschalimys ckhikvadzei* (IVPP V 8107) show distinct dentine tract
A. lingual view; B. labial view; C. posterior view; D. anterior view; E. bottom view; F. occlusal view; A-E. show distinct dentine tract

Description of left p4 (V 17928) V 17928 is a slightly worn left p4. Occlusal surface is anteriorly narrower than posteriorly, measured 3.33 mm (length) × 2.2 mm (width). The maximum length of tooth (3.72 mm) is at the middle part of the tooth shaft (column), maximum width 2.45 mm at the posterior part of tooth, maximum crown height (4.3 mm) is measured on the labial side. Ratio of height/length of the tooth is 4.3/3.72=1.16. Vertical axis of the tooth does not show obvious curve. The dentine tract between the enamel of tooth crown and the root is distinct. The protoconid and metaconid are developed, top surfaces of both conids are concave and covered with residual enamel layer, indicating that the top surfaces of both conids are concave even before wearing. Two small enamel pillarets at the anterior end, which seem to correspond to the anteroconid of *Mesogaulus novellus* (Black and Wood,

1956:text-fig. 8A), connect the protoconid and metaconid, blocking the anterior fossettid (Fig. 4F-G, 5A, E) anteriorly. The hypoconid and entoconid are higher than the protoconid and metaconid. The lingual end of the posterolophid is lower than the entoconid and is not connected with the latter (Fig. 4A-B), with wear it connects the entoconid, forming posterior fossettid that nearly fades away in section 0850 (Fig. 4K, 3.72 mm).

An enamel protuberance is present on the labial wall of the posterior fossettid, displaying on successive sections (Fig. 4C-F, 0.490–1.275 mm). The metastylid crest and the mesostylid are developed, with wear becoming connected with each other and dividing the lingual inflection into lingual fossettid and posterolingual inflection (Fig. 4C-G, 0.490–1.405 mm).

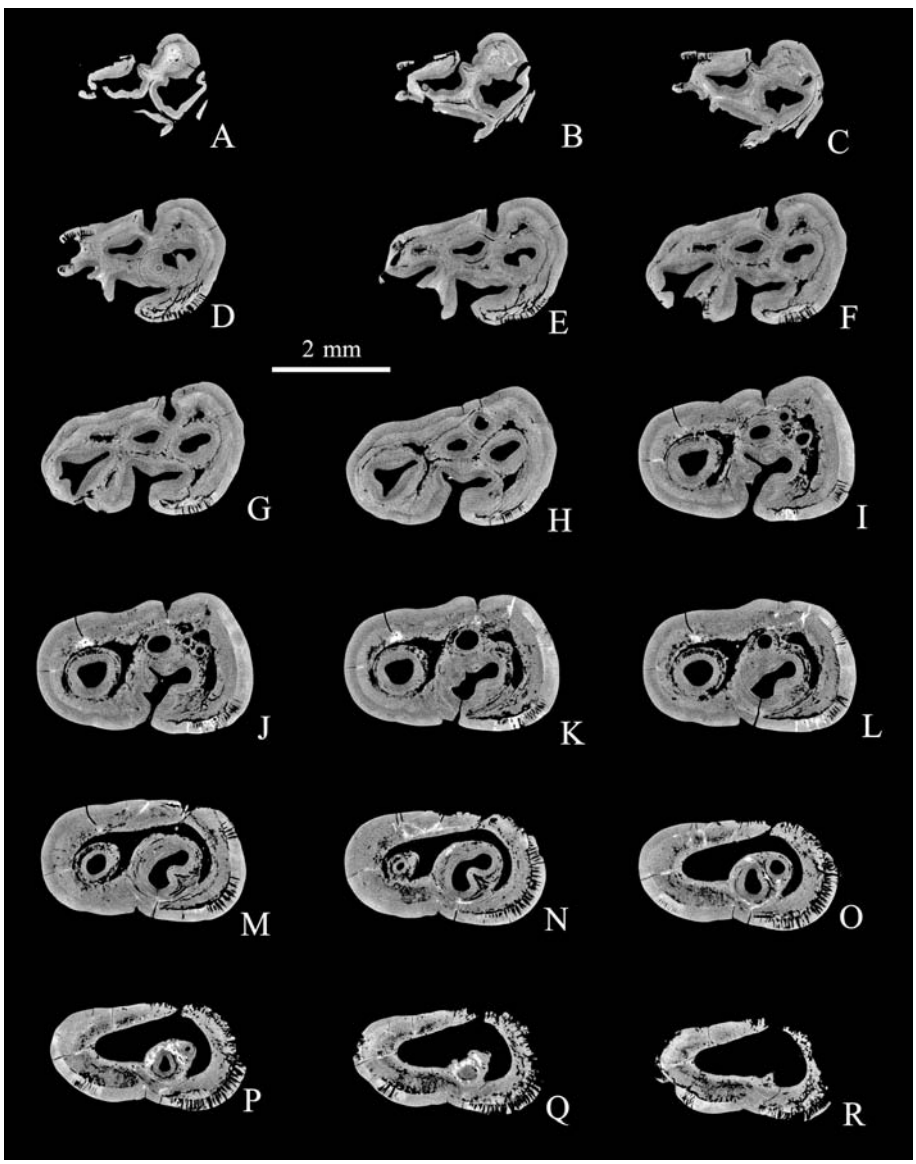

Fig. 4　Images of CT transverse sections of left p4 of *Tschalimys ckhikvadzei* (IVPP V 17928)

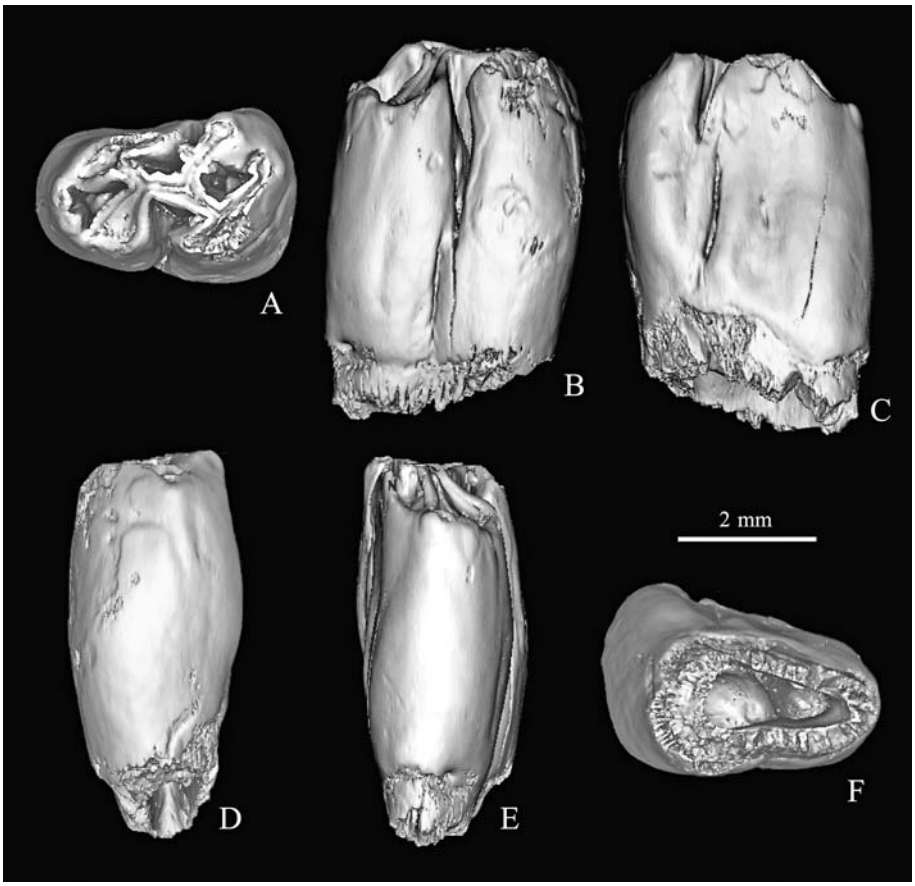

Fig. 5 Three dimensional pictures (3d stereo images) of p4 of *Tschalimys ckhikvadzei* (IVPP V 17928)
A. occlusal view; B. labial view; C. lingual view; D. posterior view; E. anterior view; F. bottom view;
B-E show distinct dentine tract

At the depth from 1.860 mm to 3.470 mm the posterolingual inflection becomes enclosed while the metastylid crest connects the entoconids (Fig. 4H-J). The mesoconid is absent on the top surface of tooth but becomes distinct and larger downwards, turning the labial inflection into an open Y-shaped inflection with anterior and posterior arms of almost equal length, the anterior one getting narrower and disappears finally, and the posterior one getting wider. With wear the protoconid and hypoconid connect with each other and block the labial inflection (Fig. 4K, 3.720 mm nearly closed, and Fig. 4L, 4.00 mm closed entirely).

Totally 1535 virtual transverse sections were generated for the p4. Eighteen of them (Fig. 4A-R) are chosen to show the occlusal morphological changes at different wear stages. The distance of each section from section 0106 (tooth top) is as follows (in mm): A–0.265, B–0.370, C–0.490, D–0.770, E–1.01, F–1.275, G–1.405, H–1.860, I–3.155, J–3.470, K–3.720, L–4.00, M–4.670, N–5.01, O–5.290, P–5.465, Q–5.560, R–5.685.

Comparison and discussion The occlusal morphology of V 8107 (P4) and V 17928 p4) is characteristic of subfamily Promylagaulinae: on P4 the anterocone expands distinctly

lingually, no appression facet for P3 is present, parastyle and mesostyle are distinct, and main cusps (paracone, metacone, protocone, protoconule and metaconule) are anteroposteriorly elongated. On p4 metastylid crest and mesostylid are developed, the mesoconid and anterior arm of labial inflection are not present at the incipient wear stage, but become more distinct with progressive wear, hypoconid becomes larger at the old age and connects with protoconid, closing labial inflection.

Outside North America mylagaulids are so far discovered only from the early Middle Miocene of Zaisan Basin of Kazakhstan and northern Junggar Basin of China in Central Asia. There are altogether 6 genera of promylagaulids in North America (Flynn and Jacobs, 2008): *Crucimys* Rensberger, 1980, *Trilaccogaulus* Korth, 1992, *Promylagaulus* McGrew, 1941, *Galbreathia* Korth 1999, *Mylagaulodon* Sinclair, 1903 and *Mesogaulus* Riggs, 1899.

Crucimys from the Arikareean (Late Oligocene to Early Miocene) of South Dakota is a monotypic genus. Species *Crucimys milleri* (Macdonald, 1970) is represented only by lower dentitions. It differs from *Tschalimys ckhikvadzei* by small size, undeveloped metastylid crest and distinct mesostylid that does not connect to metastylid crest on p4.

Trilaccogaulus from the Arikareean (latest Oligocene to earliest Miocene) of Idaho, Montana, South Dakota and Nebraska includes three species: *Trilaccogaulus ovatus*, *T. montanensis* and *T. lemhiensis*. V 17928 is very similar to the p4 of *Trilaccogaulus* in having developed metastylid crest, mesostylid, and the anterior, lingual and posterior fossettids (Rensberger, 1979:figs. 2,3; Korth, 1992:fig. 9-H-I). However its mesoconid is more developed than in *Trilaccogaulus* so that the labial inflection is Y-shaped with distinct anterior and posterior branches. V 8107 (P4) is quite different from P4 of *Trilaccogaulus* in the pattern of occlusal surface: P4 of *Trilaccogaulus* possesses 3 fossettes (Rensberger, 1979:fig. 6-b,c; Korth, 1992:fig. 9-F-G) while V 8107 has 6 fossettes. Finally, V 8107 is about twice as high as P4 of *Trilaccogaulus* (Rensberger, 1979:fig. 6-c; Korth, 1992:fig. 9-F-G).

Promylagaulus occurs in the Arikareean (latest Oligocene to earliest Miocene) of South Dakota and Nebraska, represented by only one species *Promylagaulus riggsi* McGrew, 1941. V 8107 is similar to P4 of *P. riggsi* in size, the fossettes pattern of occlusal surface, and the absence of the appression facet for P3, but differs from the latter in the more developed anterocone, the connection of the antero-labial and lingual fossettes, and in the presence of a lingual central fossette. The p4 of *P. riggsi* differs from V 17928 (p4) in more anteriorly positioned anterior fossettid (Korth, 1992:fig. 9-A-E). Furthermore, V 17928 (p4) and V 8107 (P4) are twice as high as those of *P. riggsi*: the P4 crown height of the latter is 2.01 mm on average (range 1.31–2.76), p4 1.78 mm on average (range 1.33–2.68).

Galbreathia is known from late Hemingfordian (late Early Miocene) of Wyoming and Nebraska, and early Barstovian (early Middle Miocene) of Montana and Nebraska, including 2 spceies: *G. novellus* and *G. bettae*. *Tschalimys* is obviously smaller than *Galbreathia*, and has much shorter fossettes(ids). P4 has lingual central fossette (Fig. 2C-J) but *Galbreathia* does not (Korth, 1999:fig. 2A, C).

Mylagaulodon spans from the latest Arikareean to earliest Hemingfordian (Early Miocene) of Oregon, represented by only one species *Mylagaulodon angulatus* based only on upper dentition. It is larger than *Tschalimys ckhikvadzei* in size, measured 5.5 mm × 5 mm. The paracone of P4 of this species is much less developed than in other promylagauline genera and V 8107(ref. Korth, 1992:91; Sinclair, 1903:fig. 1).

Mesogaulus from the early Hemingfordian (Early Miocene) of Montana, Colorado and Nebraska is represented by 2 species: *M. ballensis* Riggs, 1899 and *M. paniensis* (Matthew, 1902)(ref. Korth, 2000). Tooth crown is higher than that of *Tschalimys ckhikvadzei*, and with more complex pattern of wear surface, narrower and longer fossettes(ids) on P4 and p4.

The above comparison demonstrates that P4 of *Tschalimys* (V 8107) is most similar to *Promylagaulus* in occlusal pattern, and p4(V 17928) is similar to both *Promylagaulus* and *Trilaccogaulus* to some extent, but more to the latter. We are therefore not sure whether V 8107 and V 17928 do belong to the same genus and species. However we still assign them tentatively to *Tschalimys ckhikvadzei* since these two teeth come from the same locality and horizon, and both are high crowned with distinct dentine tract and match in size. The fact that *Tschalimys ckhikvadzei* is similar to *Promylagaulus* and *Trilaccogaulus*, but possesses much higher crowned tooth and occurs temporally later than the latters likely imply that *Tschalimys ckhikvadzei* is closely related to *Promylagaulus* and *Trilaccogaulus*, and derived from a lineage close to the latters.

***Simpligaulus* gen. nov.**

Etymology Simpl (Latin), simple; gaul (Greek), bucket.

Type species *Simpligaulus yangi* sp. nov.

Diagnosis Same as the diagnosis of type species.

***Simpligaulus yangi* gen. et sp. nov.**

(Figs. 6-8)

Holotype A well worn left p4 (V 17929).

Type locality Near XJ 97007(46° 39.735′ N; 88° 30.224′ E), Tieersihabahe of northern Junggar Basin.

Age and horizon Early Middle Miocene, lower part of Halamagai Formation.

Etymology In honor of late Mr. Yang Xiesheng, one of our friends and assistants from Xinjiang Production and Construction Corp, who helped us in successive field seasons for collecting and screenwashing earth samples.

Diagnosis Small sized, high crowned promylagauline. The p4 characterized by developed metastylid crest and mesostylid; metastylid crest connected to the anterolabial side of mesostylid, forming lingual fossettid; mesostylid positioned more posteriorly; labial inflection with strong posterior arm and weak anterior arm, with wear labial inflection changing into labial fossettid. The anterior- and lingual fossettids present, the posterior fossettid probably absent or very shallow.

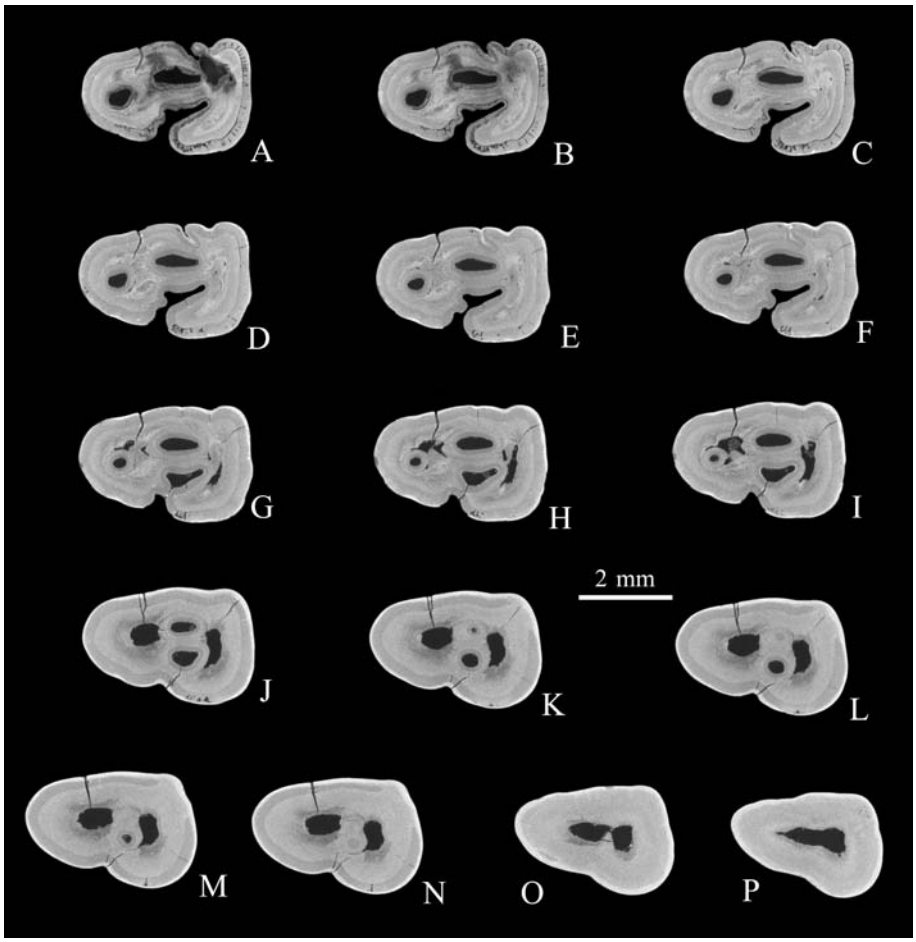

Fig. 6　Images of CT transverse sections of left p4 of *Simpligaulus yangi* (IVPP V 17929)

Description　Only a single well worn left p4 (V 17929) is available for study. Occlusal surface measures 3.67 mm (length) × 2.54 mm (width), narrow and round anteriorly, wide posteriorly. A distinct wear facet with the m1 behind it is present. The dentine tract between tooth crown and root is not visible in the original three dimensional pictures (Fig. 7) because of the mineralization of the tooth surface. A special technique was used (by Ni Xijun) to digitally "corrode" the mineralized material to make the EDJ (enamel dentine junction) more distinct (Fig. 8). The height of crown plus root is 6.48 mm labially, 6.16 mm lingually. The remaining crown height is 2.66 mm labially and 2.54 mm lingually. Tooth column slightly convex labially. Both metastylid crest and mesostylid are developed but the mesostylid is positioned rather posteriorly. The metastylid crest connects the mesostylid on the anterolabial side of the latter and closes the elongated lingual fossettid which fades away downwards and almost disappears at Fig. 6K (1.695 mm). The mesostylid protrudes on the lingual side of the tooth but disappears on Fig. 6E (0.665 mm). The anterior fossettid between the protoconid and

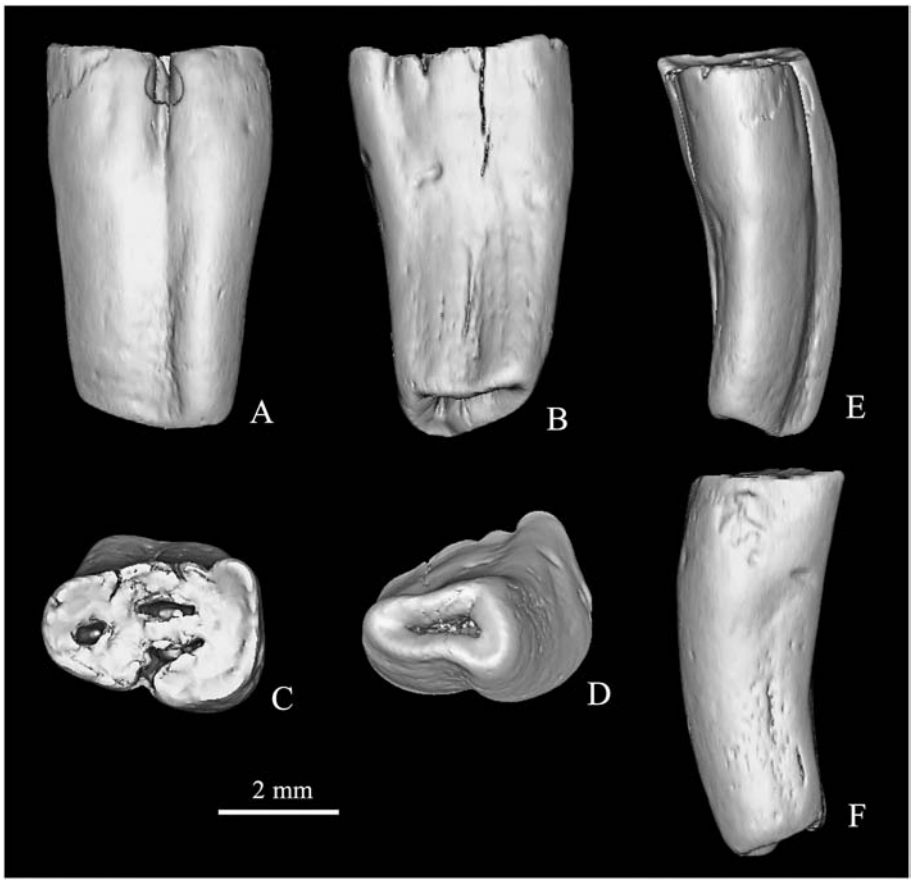

Fig. 7 Three dimensional pictures (3d stereo images) of p4 of *Simpligaulus yangi* (IVPP V 17929)
A. labial view; B. lingual view; C. occlusal view; D. bottom view; E. anterior view; F. posterior view

metaconid is approximately oval, disappears at Fig. 6J (1.415 mm). No trace of the posterior fossettid is present at any section. If any it must be very shallow and worn away at the earliest wear stage of the tooth. The labial inflection extends posterolingually. The mesoconid is weak at the top surface but getting slightly more distinct towards the root, the labial inflection displays consequently obvious anterior and posterior branches, the posterior one is much longer and narrower than the anterior one. A protuberance is present on the posterior wall of the protocone, it becomes larger downwards gradually, making the anterior branch of the labial inflection more distinct, finally closing the labial inflection, and turning inflection into fossettid (Fig. 6G, 0.82 mm). The latter disappears at Fig. 6N (1.94 mm), and all fossettids fade away just at this wear stage, leaving only two pulp cavities.

Totally 1426 virtual transverse sections are reconstructed for p4(V 17929). Sixteen sections (Fig. 6A-P) are illustrated to show occlusal morphological change of the tooth at different wear stages. The distance of each section from the occlusal surface is as follows (in mm): A–0.32, B–0.35, C–0.42, D–0.545, E–0.665, F–0.715, G–0.82, H–0.925, I–0.995,

J–1.415, K–1.695, L–1.73, M–1.87, N–1.94, O–2.655, P–2.995.

Comparison and discussion　The fact that V 17929(p4) has developed metastylid crest and mesostylid, undeveloped mesoconid, and the posterolingually extended labial inflection with weak anterior branch, indicates its pertaining to promylagaulines. It is characterized by having only two fossettids in addition to the labial inflection and absence of posterior fossettid. It is of course possible that the posterior fossettid is present but is very shallow, just like *Promylagaulus riggsi* from Nebraska (Korth, 1992: bottom line of p.94 to top line of p.95, fig. 9-E), and disappears not long after moderate wear. The remaining crown height of V 17929(p4) is 2.66 mm labially and 2.54 mm lingually. It means that its posterior fossettid (if it is really present) should disappear at least at the height of 2.66 mm or even earlier. On the contrary specimen V 17928, p4 of *Tschalimys ckhikvadzei*, the posterior fossettid disappears at the distance 0.83–0.58 mm from the bottom of the tooth crown, while the total crown height of V 17928 is 4.3 mm. It means that the posterior fossettid of *Tschalimys ckhikvadzei* disappears at a rather late wear stage of the tooth. Based on the above discussion specimen V 17929(p4) should not be assigned to the same genus and species as V 8107 (P4) and V 17928 (p4) though they come from the same area and same horizon.

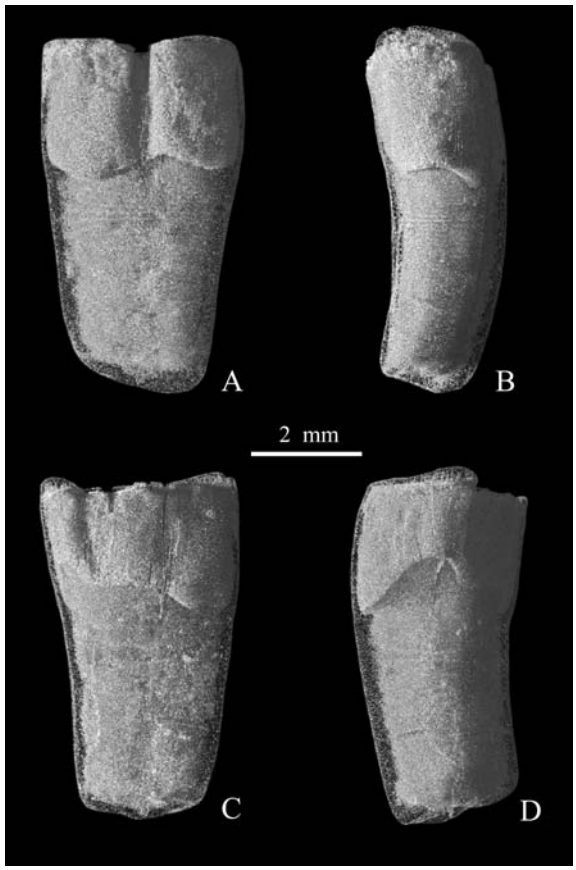

Fig. 8　Three dimensional pictures (3d stereo images) showing the dentine tract of p4 of *Simpligaulus yangi* (IVPP V 17929) A. labial view; B. anterior view; C. lingual view; D. posterior view

V 17929 differs from *Crucimys* in having larger size, higher crown and developed metastylid crest which connects to the mesostylid, while in *Crucimys* the metastylid crest is short and does not connect to the mesostylid.

V 17929 is similar to *Trilaccogaulus* and *Promylagaulus* in size but different in the occlusal pattern. Besides the labial inflection the p4 of *Trilaccogaulus* has three fossettids which persist until deeply worn, and the p4 of *Promylagaulus* has rather small anterior and posterior fossettids and lacks lingual fossettid because of the short metastylid crest. V 17929 is higher crowned than *Trilaccogaulus* and *Promylagaulus*: the ratio of height to length for p4 of *Trilaccogaulus ovatus* and *Promylagaulus riggsi* ranges 0.49–0.60 and 0.38–0.71 respectively

(Korth, 1992:table 7), while 3.24/3.67=0.88 for V 17929, taking half of the remaining height of tooth (=remaining crown height plus root height) as original crown height.

Mesogaulus and *Galbreathia* are larger in size and possess complex occlusal pattern with longer and narrower fossettids. As regards *Mylagaulodon* there is so far no record on its p4.

It is obviously that V 17929 should represent a new genus of Promylagaulinae. Considering the occlusal outline and the shape of labial inflection it seems more closely related to *Promylagaulus* (Korth, 1992:fig. 9-E) than to other genera, and derived from a form relative to *Promylagaulus*.

Ecological environments of mylagaulids of early Middle Miocene in northern Junggar Basin Mylagaulidae is an extinct group of Aplodontoidea, originates in the Late Oligocene and diversifies through Miocene in North America. Mylagaulid fossils had not ever been discovered outside central and western North America until 1971 when Shevyreva reported the first find of Mylagaulidae from Zaisan Basin of Kazakhstan in Central Asia. Since 1980s new mylagaulid fossils have been found from northern Junggar Basin of China (Wu, 1988). The discovery of mylagaulids in Central Asia, though few in number, provides additional information on the morphology of the mylagaulids, and is of importance for further understanding the phylogeny, ecology, diversification and migration of these animals. The forms we described herein have shown close relationships to their American relatives.

Apolodontia rufa (mountain beaver), the only living aplodontid and the relative of mylagaulids, inhabits the humid regions of western North America. It was reported that the animals frequent forests and densely vegetated thickets. They burrow in soil which is moderately firm and deep and has adequate drainage. Most of them live in areas where there is heavy rainfall, and the ground is usually saturated with water (Walker, 1975).

The Halamagai Formation is a set of grayish green lacustrine and fluvial sediments from which *Simpligaulus yangi* and *Tschalimys ckhikvadzei* were discovered. Associated fauna with them is of high diversity, consists of crocodiles and at least 49 mammal species including proboscidean, primates, castors etc., indicating a warm and wet environment. The recent comprehensively lithological, paleontologic and paleomagnetic studies on the Cenozoic stratigraphy in the northern Junggar Basin (Meng et al, 2008; Ye et al, 2012) demonstrate that the ecological environment of Halamagai fauna is coincident with the Mid-Miocene Climatic Optimum (Zachos et al., 2001), there is probably a causal relationship of the Halamagai fauna with the global climate. We infer that *Simpligaulus yangi* and *Tschalimys ckhikvadzei* also prefer warm and humid environment during this period of time, and they are immigrants from west North America or the descendants of the immigrants in Central Asia. It remains unclear when the promylagaulines began to migrate to Central Asia, how many times of such a migration had taken place, and how they diversified after their arrival.

McKenna and Bell (1997) assign *Sinomylagaulus* and *Tschalimys* to Aplodontoidea Brandt, 1855 and Aplodontidae Brandt, 1855 respectively but not to Promylagaulinae. In the present paper we attribute both *Tschalimys* and *Simpligaulus* to Promylagaulinae because of their high morphological similarity to the latter.

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新疆准噶尔盆地北缘中中新世早期的原圆齿鼠 (Promylagaulinae, Mylagaulidae)

吴文裕[1]　倪喜军[1]　叶　捷[1]　孟　津[1,2]　毕顺东[1,3]

(1 中国科学院古脊椎动物与古人类研究所　北京　100044)

(2 美国自然历史博物馆　纽约　NY10024)

(3 美国宾夕法尼亚州印第安纳大学生物系　印第安纳　PA15705)

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1988年吴文裕描述了产自新疆准噶尔盆地北缘铁尔斯哈巴合地点哈拉玛盖组下部层位的一枚圆齿鼠的P4, 定名为*Sinomylagaulus halamagaiensis*。1997年中国科学院古脊椎动物与古人类研究所新疆考察队又在铁尔斯哈巴合的哈拉玛盖组下部层位中采集到两枚p4。1988年的研究工作仅依据一枚上前臼齿(P4), 标本的稀缺决定了当时研究成果的局限性。新材料无疑为认识新疆的圆齿鼠类提供了新的信息，因此有必要将新旧材料一起进行研究。

由于我们的研究对象为具有多个不同深度的釉质凹的高冠齿，这些釉质凹的大小、形状和数量随牙齿的磨蚀程度而变化，因此为标本间的对比和属种的正确判断带来了一定的困难。McGrew (1941:23)是将切片法应用到圆齿鼠类研究中的第一人。Black and Wood (1956)在研究北美中新世的*Mesogaulus novellus* (现归*Galbreathia*属，下同)时也采用了切片法，按1 mm的间距观察牙齿磨蚀面的变化。但由于我们拥有的标本量太少，如果采用此法，则标本不复存在。所幸近年来CT技术被越来越广泛地应用到古生物研究领域，我们在研究新疆的圆齿鼠时采用CT技术，可以在不破坏牙齿的前提下观察研究牙齿在不同磨蚀阶段咀嚼面构造的变化，为研究工作提供了很多方便。

我们的CT断面间距为5 μ (4.987 μ), 因此很容易计算出每个断面在齿冠上的位置。尽管计算出的断面与咀嚼面之间的距离会有一定的误差，但这不影响我们观察各咀嚼面图形变化情况。

借助CT断层扫描技术的研究结果表明，其中哈拉玛盖中国圆齿鼠*Sinomylagaulus halamagaiensis* Wu, 1988应是奇氏察里圆齿鼠*Tschalimys ckhikvadzei* Shevyreva, 1971的晚出

同物异名，另一种为杨氏简圆齿鼠(新属新种)*Simpligaulus yangi* gen. et sp. nov., 这两属种都应归入原圆齿鼠亚科。对新疆准噶尔盆地北缘晚渐新世至晚中新世地层的岩石、古生物和古地磁综合研究表明，哈拉玛盖组是中中新世全球气候最佳期暖湿气候条件下的沉积物。推测*Tschalimys ckhikvadzei*和*Simpligaulus yangi*的生活习性与现生山河狸相似，居住在湿润的森林和稠密的灌丛地带，中亚的原圆齿鼠类有可能是由北美西部迁徙而来。

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