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NARRATIVE OF THE KOREA-MONGOLIA INTERNATIONAL DINOSAUR EXPEDITIONS (KID) 2006-2010 WITH SCIENTIFIC RESULTS

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ABSTRACT The Korea-Mongolia International Dinosaur Expeditions (KID) were initiated by the discovery of the most significant dinosaur egg site known in South Korea, and as one project associated with the construction of a new dinosaur museum at Hwaseong City. It ran for five years (2006-2010) and involved 33 researchers from eleven countries supported by twenty-seven Mongolian staff. Since the American Museum of Natural History expeditions in 1923-1930, they were the first multi-international dinosaur expedition in Mongolia, and the first international dinosaur expedition organized by Korea. These expeditions worked mainly in Upper Cretaceous formations, including the Bayanshiree and Javkhlant formations in the eastern Gobi and the Baruungoyot and Nemegt formations in the southwestern Gobi. The KID expeditions succeeded by collecting 694 cataloged specimens and produced meaningful paleontological research on *Bagaceratops*, *Deinocheirus*, *Gobiraptor*, *Harenaichthys, Natovenator*, *Nemegtonykus*, *Prenocephale*, *Talarurus*, and *Tarchia*. In addition, comprehensive stratigraphic correlations were completed in the famous dinosaur localities in eastern and southern Gobi. The KID expeditions successfully promoted international research cooperation, built valuable collections, fostered the education of graduate students, and accelerated the development of a museum in South Korea.

KEYWORDS KID expedition, Hwaseong City, Dinosaurs, Gobi Desert, Mongolia

INTRODUCTION

The largest dinosaur egg site known in the Korean Peninsula was discovered in 1999 at Hwaseong City, Gyeonggi Province, near Seoul. To date, more than 200 dinosaur eggs of four different kinds (dongyangoolithid, elongatoolithid, faveoloolithid, and stalicoolithid), including 29 clutches, have been discovered in the reddish conglomeratic sandstone beds (Early Cretaceous, Sihwa Formation) of nine small islands in a salt marsh, indicating the first discovery of dinosaur colonial nesting ground in Asia (Lee, 2003). Because of this locality's unique setting and scientific importance, the Korean government designated 1.5 km^2 as a National Monument in 2000. And Hwaseong City began planning for the construction of a new dinosaur museum with extensive collections and research facilities. Therefore, Hwaseong City sponsored Y.-N. Lee for five years to carry out the Korea-Mongolia International Dinosaur Expeditions (nicknamed the KID expeditions). After KIGAM (Korea Institute of Geoscience and Mineral Resources, where Y.-N. Lee worked) entered into an official research agreement with the Institute of Geology of Mongolian Academy of Sciences in 2006, KIGAM additionally made a research partnership with Southern Methodist University (Louis L. Jacobs), USA, and the University of Alberta (Philip J. Currie), Canada. The KID expeditions ran for about 40 days in the Gobi Desert between August and September every year from 2006 to 2010. The team crew was augmented each year by additional researchers from various countries including Argentina, Australia, Canada, China, Denmark, Japan, Portugal, Slovenia, and the USA. Consequently, this project was the first large multi-international dinosaur expedition in the Gobi since the famous Roy Chapman Andrews' expeditions of the American Museum of Natural History (AMNH) from 1923-1930. Each year, the KID crew consisted of around 15 researchers on average, with ten Mongolian staff, including drivers and cooks (Appendix 1). We neither hired laborers nor medical doctors. Three Russian military trucks (models GAZ-66, KAMAZ-43114, ZIL-131),

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jeeps, and mini-vans were usually used for transportation. The purpose of this expedition was to discover, collect and study scientifically important dinosaurs from the Gobi Desert in Mongolia, which is one of the most important dinosaur areas in the world, and to collect displayable specimens for the new dinosaur museum at Hwaseong City.

The KID expeditions were carried out in famous localities known from American, Mongolian, Polish, and Soviet expeditions. Except for the first half of the second expedition in the eastern Gobi in 2007, the rest of the expeditions worked in the southwestern Gobi, where we explored Altan Uul, Bugiin Tsav, Guriliin Tsav, Hermiin Tsav, Khuree Tsav, Nemegt, Nogoon Tsav, Tsagaan Khushuu, and Ulan Khushuu (Table 1, Fig. 1). From these regions, we discovered a variety of dinosaur fossils and other vertebrate fossils from the Baruungoyot and Nemegt formations (middle Campanian? to early Maastrichtian). In the eastern Gobi in 2007, the Bayanshiree and Javkhlant formations (Cenomanian to Santonian?) were explored at Bayan Shiree, Khar Khutul, and Shine Us Khudag. These localities also produced a rich assemblage of vertebrate fossils, especially dinosaurs.

Here, we briefly describe each expedition by year for the journey, the localities we explored, discoveries, and scientific results.

TABLE 1. The dates and localities of the KID expedition

	Date	Localities
1st	2006.08.30 - 10.03	Altan Uul I-IV, Ulaan Khushuu, Bugiin Tsav, Guriliin Tsav, Nemegt
2nd	2007.08.16 - 09.21	Shine Us Khudag, Khar Khutul, Bayan Shiree, Hermiin Tsav, Nogoon Tsav
3rd	2008.08.15 - 09.24	Hermiin Tsav, Bugiin Tsav, Altan Uul II, III, Nemegt
4th	2009.08.03 - 09.09	Bugiin Tsav, Tsagaan Khushuu, Altan Uul, Nemegt
5th	2010.08.23 - 10.01	Bugiin Tsav, Guriliin Tsav, Khuree Tsav, Nogoon Tsav, Altan Uul, Nemegt

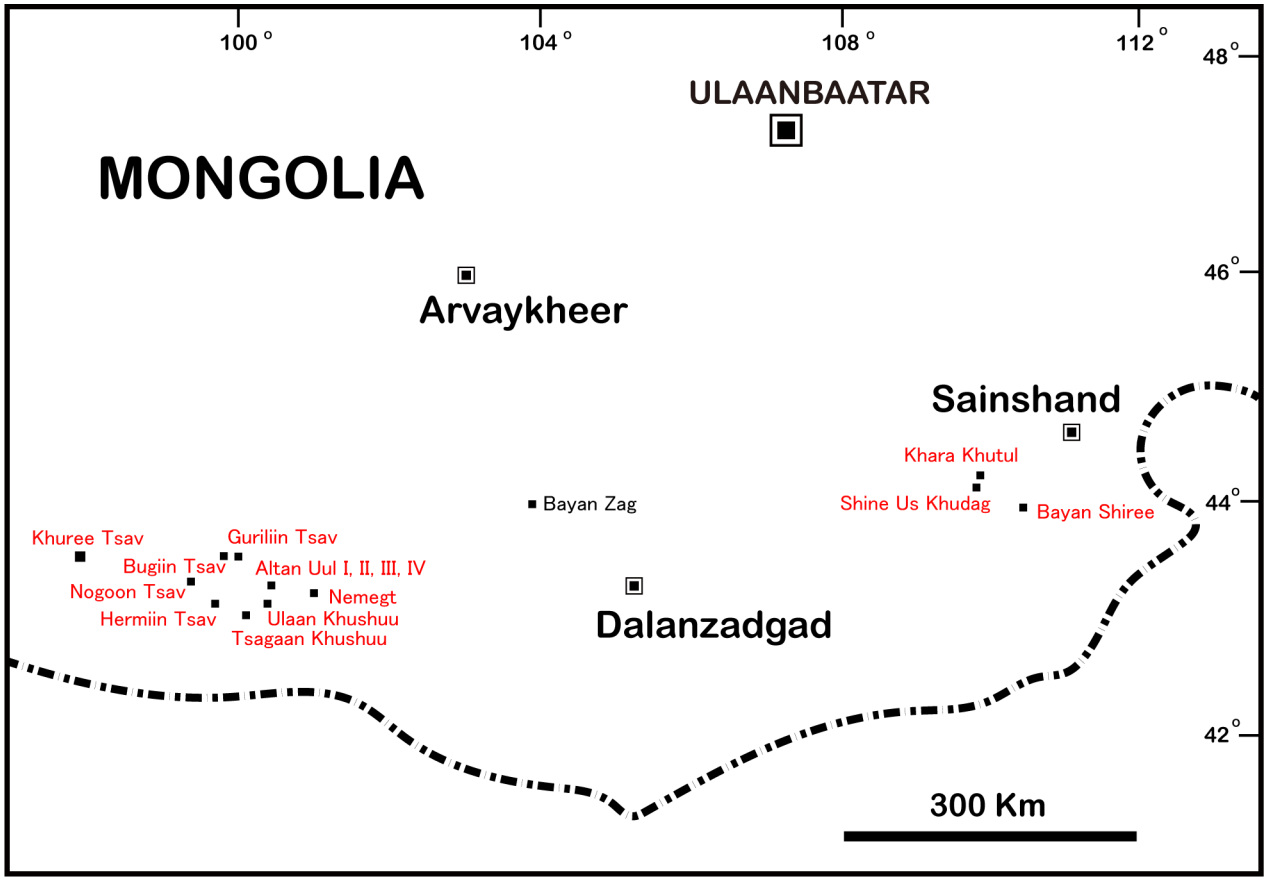

FIGURE 1. Explored localities (red color) in the eastern and southern Gobi (modified from Watabe and Suzuki, 2000, fig. 1).

2006 EXPEDITION

The first KID expedition was carried out over a period of 35 days between August 30 and October 3. The field crew comprised 24 people (15 researchers and nine Mongolian staff, including the field manager, six drivers, and two cooks) (Appendix 1). On August 21, the field gear for the Korean group was sent by DHL from Seoul to Ulaanbaatar. From August 30, all field equipment with food was prepared and loaded into the two GAZ trucks by the Korean and Mongolian contingents. All other researchers arrived in Ulaanbaatar on September 1 and 2 from Canada, Japan, and the USA. The flight of Lü was delayed for 14 hours in Beijing due to strong winds at the Chinggis Khaan International Airport, and he arrived one day later than the original schedule. Official meetings in which a detailed expedition plan was finalized were held in the Paleontological Center between September 1 and 3. Altan Uul, Bugiin Tsav, Guriliin Tsav, and Ulaan Khushuu were selected as destinations for prospecting the Nemegt Formation. The main target was the Altan Uul (I, II, III, IV) area. All foreign researchers applied for visa extensions at the Mongolian Immigration Agency so that they could stay more than one month.

Two GAZ trucks left on September 3, which was one day earlier than the field crew. On September 4, the rest of the expedition members left in one jeep and three vans for Arvaykheer, the last big central city before entering the Gobi region. In the afternoon, we caught up with one of our trucks, which had broken down on the road approximately 200 km from Ulaanbaatar. The front wheel bearings needed to be replaced. Ligden Barsbold, the field manager, went back to Ulaanbaatar to get new bearings, and we kept moving forward after moving the broken truck's load to another truck. Ligden returned with new parts the next day, and the Mongolian mechanics fixed the truck. We passed Arvaykheer in the afternoon and camped north of Guchin Us on September 5. It snowed that night, when Ligden went back to Arvaykheer to buy truck parts. On September 6, the same truck broke down again 32 km before reaching Bogd. We left the truck, moved to the Shireegiin Gashuun Basin, and camped at the east end of Nemegt Mountain. The broken truck came to our camp in the evening, and Mongolian mechanics worked on fixing the truck all night. The next day, we passed a narrow gorge between Gilbent and Nemegt mountains and passed into the southern Gobi region. We rented a ger from a nomadic family and finally arrived at Ulaan Khushuu during the afternoon on September 7. The base camp was set up after spending four days on the road-twice as long as expected because of mechanical problems.

On September 8, we began prospecting at Altan Uul III. We found many isolated bones, various dinosaur teeth, and eggshells. Nine specimens were cataloged on the first day. Interestingly, we found a microvertebrate site near the base camp, containing many isolated fish vertebrae and dinosaur teeth. Compared with abundant dinosaur faunas, fish fossils (other than isolated centra) are scarce in the Nemegt Formation. All fish material from Altan Uul, Bugiin Tsav, Hermiin Tsav, and Ulaan Khushuu collected during the KID expeditions was identified as a new species of Osteoglossomorpha now known as *Harenaichthys lui*, which is the first and only reported fish taxon of the Nemegt Formation (Kim et al., 2022). We collected sauropod teeth and a *Tarbosaurus* coracoid and lacrimal at Altan Uul III the next day. By 2006, the poaching of dinosaur skeletons had become a significant problem. Its effects were visible throughout the field area. We determined that the origin of *Raptorex kriegsteini* is the Nemegt Formation, and may even have come from one of the poached quarries that we saw (Kim et al., 2022).

On September 10, an articulated *Tarbosaurus* pelvic girdle (with an ilium length of 112 cm) with all sacral and eight proximal caudal vertebrae (KID 022) was found at Altan Uul IV. Although we encountered many *Tarbosaurus* remains, mainly at poached quarries in various localities, it was the first major excavation of a *Tarbosaurus* specimen in 2006. We spent five days on the excavation because it was in hard sandstone. On September 15, all *Tarbosaurus* plaster jackets were moved to the camp except for the biggest one. On the same day, a poached quarry was found in another canyon (sayr) at Altan Uul IV, where ilia with dorsal and sacral vertebrae (MPC-D 100/128) were found scattered across a slope. Because the ilium shape and long neural spines of dorsal and sacral vertebrae were quite different from those of other dinosaurs, we tentatively identified it as a "therizinosaur," speculating that it would be *Therizinosaurus*, a mysterious dinosaur mostly known from giant arms with elongate claws.

On September 16, we headed to Bugiin Tsav in reconnaissance for the next expedition. The landscape of Bugiin Tsav consists mainly of low rounded exposures that are very different from the deep gorges of Altan Uul. Turtle shells are abundant, but are often associated with isolated skulls. The next day, a few

FIGURE 2. A jacket of *Tarbosaurus* (ilia with sacral vertebrae) on the top of the hill at Altan Uul IV (KID 022) was being dragged down to the hill only by human resources with ropes on September 18, 2006.

bones were collected at Ulaan Khushuu. On September 18, we went back to the top of the hill at Altan Uul IV to collect the largest plaster jacket (weighing more than 500 kg) of the *Tarbosaurus* (ilia with sacral vertebrae). We dragged it down the hill and loaded into the truck using only human power and ropes (Fig. 2). Ironically, we subsequently learned that our quarry was close to where the Polish-Mongolian Paleontological Expedition had collected the holotype of *Opisthocoelocaudia* in 1965, and they had dragged the jackets down the same trail and loaded them onto trucks in the same area (which they called "the Café"). Polish graffiti still adorns the sandstone walls of the canyon where the specimens were crated.

A beautifully preserved, articulated tail was also excavated at the "therizinosaur" site on the same day. Subsequently, this specimen was identified as a subadult *Deinocheirus* (Lee et al., 2014).

On September 19, we visited the "Dragon's Tomb" at Altan Uul II, which is a bonebed of the giant hadrosaurine, *Saurolophus angustirostris*. Although the Soviet expeditions of the 1940s had excavated many articulated specimens, we collected mostly skin impressions that had been left behind. Those specimens were used to standardize the terminology of hadrosaurid skin impressions (Bell, 2012).

The next day, we visited Altan Uul I, which has fewer and smaller outcrops, and more shallow gorges than other Altan Uul localities. Nevertheless, we found that bones and eggs were abundant. We collected a *Gallimimus* postcranial skeleton containing a complete tail at a poached quarry. At the camp, we met Barsbold and the American group (Fiorillo, Jacobs, and Newman), who arrived three days late after waiting for lost luggage to show up at the airport.

On September 21, the expedition team, which gained new vitality by the addition of the American group, headed for Altan Uul III again. In an abandoned quarry, Y.-N. Lee found a juvenile *Tarbosaurus* skeleton (KID 069). Although some bones, including the skull, had been taken by poachers, many postcranial elements were left untouched in the blocks. They

included 14 articulated vertebrae (posterior dorsals, sacrals, and proximal caudals), a left manus, an articulated pelvic girdle, both femora, an incomplete tibia and fibula, right distal tarsals, phalanges, and complete gastralia. Eighteen segments of gastralia are preserved in life position. Inside the left side of the gastral basket, fossilized stomach contents were found for the first time in *Tarbosaurus*. This specimen is now under study.

A new ornithomimid skeleton (KID 101) was also found on the same day near the camp. It was almost a complete skeleton, including the braincase. Based on the unique manual claws, it differs from *Anserimimus* and *Gallimimus,* which are the only known ornithomimids from the Nemegt Formation. Consequently, it may be a new taxon of ornithomimids. These two were the most exciting specimens discovered, along with the *Deinocheirus* (MPC-D 100/128), that were found in 2006.

From September 22 to 23, all team members excavated KID 069 and KID 101 during the day and made plaster jackets in the evening at the camp. The American group collected dinosaur eggshells and carbonate nodules to test for paleoenvironmental and paleoecological parameters important in dinosaur evolution. They were studied by examining diagenesis using light microscopy, SEM, and cathodoluminescence with $\delta^{13}C$ and $\delta^{18}O$ values (Graf et al., 2018). On September 24, all members worked at the mud-dominant Guriliin Tsav, where many turtles (mainly *Mongolemys*) were found along with *Saurolophus* and *Tarbosaurus* at poached quarries. The next day, we finished excavating KID 069 and KID 101.

On September 26, the Canadian group returned to Ulaanbaatar, and the American group headed to Nemegt for reconnaissance. The rest of the team disassembled the camp, packed the specimens, and loaded 65 plaster jackets in 36 boxes into the trucks. Two trucks left for Ulaanbaatar the next day, and the team returned to Ulaanbaatar on September 29 via Bayan Zag.

2007 EXPEDITION

The second KID expedition lasted 38 days, from August 16 to September 21. The field crew comprised 27 people (17 researchers and ten Mongolian staff) (Appendix 1). Through official meetings in the Paleontological Center, Shine Us Kudag in the eastern Gobi and Hermiin Tsav in the southern Gobi were picked for exploration. Before heading to the first base camp at Shine Us Kudag on August 20, all members from Canada, Japan, Korea, Portugal, and the USA arrived in Ulaanbaatar. Martin Kundrát from Slovakia joined our expedition at Barsbold's request. Like last year, two trucks (GAZ, ZIL) hauling a big water bowser left one day earlier than the rest of the team. Therrien and Zelenitsky were left behind because their luggage did not arrive until the departure day. On August 20, we met our trucks at Sainshand in the evening, moved 200 km further, and arrived in Shine Us Khudag at 11:00 PM.

On the first working day, all members visited the sauropod quarry found by Kobayashi's group near the base camp two years previously. Several cervical and caudal vertebrae had already been collected on a small hill, and were stored in the Paleontological Center. We decided to excavate this animal (KID 106) because sauropods are rare in the Bayanshiree Formation. *Erketu* was the only known sauropod in the Bayanshiree Formation (Ksepka and Norell, 2006; 2010), and had been found in Bor Guvé, 23 km from the KID 106 site.

Two formations are distributed in the vicinity of Shine Us Kudag: the Bayanshiree Formation (280 m thick) and the Javkhlant Formation (380 m thick). The Javkhant Formation is broadly exposed in Shine Us Kudag and Khar Khutul, and consists of massive red siltstones. The stratigraphic relationship between these two formations was uncertain, but it was clarified through detailed fieldwork this year (Eberth et al., 2009) that the Javkhant Formation conformably overlies the Bayanshiree Formation. The Shine Us Kudag area is relatively flat with low hills, so outcrops are distributed as patches.

Therrien and Zelenitsky arrived at the camp in the evening of August 21. On August 22, one group began excavating the sauropod using two jackhammers and shovels to remove the overburden, while the other group searched for fossils in the Bayanshiree Formation, where they found a therizinosaurid femur (KID 113). The next day, it rained in the morning, and there was a sandstorm in the afternoon. On August 24, the sauropod quarry was getting too large, and many bones needed to be excavated in a few days to finish. Nishida found and kept digging an ankylosaur (KID 155) containing the pelvic girdle, dorsal vertebrae, and hindlimbs. The following day, Y.-N. Lee and Lidgen visited a uranium mining company nearby to rent an excavator. Many significant sandstone-hosted uranium occurrences have been found in the eastern Gobi in proximal Cretaceous sedimentary basins. Very low radioactivity can be detected in dinosaur bones collected in

FIGURE 3. Excavating a sauropod (KID 106) at Shine Us Kudag on August 31, 2007.

this area. The manager of the uranium company promised to help us the next day. At the sauropod quarry, pelvic girdles were newly exposed with dorsal vertebrae and ribs. On August 26, the excavator arrived at the quarry in the morning and began to remove the overburden. With the help of the excavator, 62 bones were located within 117 m^2, which include almost all postcranial elements except for the proximal cervical and distal caudal vertebrae, the manus, and the pes.

On August 27, the plaster jacketing began for some isolated bones while the main block was excavated in a sauropod quarry. Two small ceratopsians (KID 148, 150), probably *Yamaceratops*, were collected in the Javkhlant Formation. The next day, most of the crew went to the type section of the Bayanshiree Formation at Bayanshiree, 50 km from the base camp. A microsite was found there, containing ankylosaurid, ornithopod, and theropod teeth and claws, an ornithomimid phalanx, fish vertebrae, crocodyliform teeth and scutes, turtle bones, and eggshell fragments (KID 139). On August 29, Lidgen left for Ulaanbaatar to pick up Currie, Koppellhus, and Ryan and to get food, plaster, and acetone. Four plaster jackets were made for the ankylosaur body (KID 155). Mapping was finished at the sauropod quarry before everything was encased in plaster jackets. From August 30 to 31, the Canadian group searched for fossils and investigated the stratigraphy and geology in the Bayanshiree Formation distributed in the Black Mountain area of Khar Khutul. Twelve jackets were made at the sauropod quarry (Fig. 3).

On September 1, while four more jackets were made at the sauropod quarry, Kobayashi, Mateus, Therrien, and Zelenitsky visited Bayanshiree and found two *Talarurus* skulls (MPC-D 100/1354, 1355). Although *Talarurus plicatospineus* was reported by Maleev (1952), the holotype skull only includes part of the back of the skull. Therefore, the new skulls provided new details of the cranial osteology of *Talarurus* (Park et al., 2020). Thanks to the well-preserved braincase, the detailed endocranial morphology of *Talarurus* was also revealed for the first time (Paulina-Carabajal et al., 2018). Currie's contingent arrived at the camp in the evening without the truck (GAZ), which was stuck in the mud 20 km from Sainshand. After dinner, Ligden and two drivers returned to Sainshand with another truck (ZIL) for towing. The next day, jacketing of the sauropod blocks continued while the Canadian contingent worked at Khar Khutul.

However, Ligden did not come back to the camp until the morning. Y.-N. Lee, Chenbur, Kundrát, and Lkhaasuren drove to Sainshand to find our two trucks. On the way, we met our GAZ being towed. Ligden drove back to Ulaanbaatar to get truck parts with Kundrát, and we returned to the camp with two trucks. With plaster loaded in a towed truck, we kept making jackets.

On September 3, one group excavated the two *Talarurus* skulls at Bayanshiree while the other group continued to make plaster jackets for the sauropod. Ligden returned to the camp with truck parts and worked the whole afternoon on repairing the GAZ. The next day, the sauropod quarry was closed with 30 plaster jackets removed. The Canadian contingent plus Mateus collected one more *Talarurus* skull (MPC-D 100/1356) at Bayanshiree. Because the GAZ was not ready to move, we emptied the ZIL so that we could load all jackets in it. On the morning of September 5, Y.-N. Lee and the Mongolian staff went to the mining company with the ZIL full of plaster jackets collected in Shine Us Kudag. We asked the company to store our jackets while we continued our expedition to the southern Gobi. After dissembling the camp, we finally moved out at 3:00 PM. However, the GAZ stopped after a short distance because of a defective camshaft and we were forced to spend the night in the middle of nowhere. Lidgen called the Paleontological Center to bring another truck to Dalanzadgad. The next day, we moved to Mandakh with one jeep, three vans, and the ZIL towing the GAZ. At Mandakh, a small village, there was one old GAZ that was not working. Lidgen bought its engine from the owner, and used it to replace the engine in ours. The drivers worked for the next six hours to switch the engines. We were all amazed that it was possible for the drivers to exchange the truck engines under such primitive conditions, and at 10:30 PM, the expedition left town. We stopped to camp at 11:30 PM between Mandkh and Manlai, but had only progressed 140 km from our camp of the previous night.

On September 7, we did not arrive in Dalanzadgad until 6:00 PM. After buying some supplies and food, and having supper in a local restaurant, we finally checked into a ger hotel at midnight. We got an early start the next morning, but because of continued vehicle problems, we did not arrive at Hermiin Tsav until the afternoon of September 10. Song found a concretion containing a partial skull and body of *Bagaceratops* (KID 196) in the Baruunyogot Formation near camp. Although *Bagaceratops* is well known for skulls of various ontogenetic stages, the description of the postcranial skeleton of this specimen was the first for *Bagaceratops* (Kim et al., 2019). The lower Nemegt and Baruungoyot formations are widely distributed at Hermiin Tsav (Eberth, 2018). Prospecting the next day produced a nest of dinosaur eggs with embryos (KID 202) in the Nemget Formation, and a few *Gobipteryx* eggs in the Barrungoyot Formation.

Prospecting continued on September 12, and produced a *Tarbosaurus* maxilla (KID 206) and a crocodyliform skull (KID 205) from the Nemegt Formation. The next day, while Kobayashi, Therrien, and Zelenitsky excavated the nest of eggs (KID 202), most of the crew left in the early morning to prospect at Nogoon Tsav, which was 55 km in a direct line from camp. We had to make a major detour to get around the vast, low sandy region at the center of the basin, and did not arrive at Nogoon Tsav until 3:00 PM. We only had time to look around for an hour, but found natural casts of theropod and hadrosaur footprints, and many turtle shells. The lithology and fossils were similar to those of Guriliin Tsav. Because it was getting late, we took a different road north from Nogoon Tsav that the drivers thought was a shortcut. However, this turned out to be a terrible mistake. In the evening, we passed by the south escarpment of Hermiin Tsav, only 14 km from camp, but there was no road down into the canyon. As darkness fell, we were forced south along a narrow mountain road. We climbed to the top the mountain 45 km south of the camp at midnight, and almost ran out of gas. Fortunately, we found a ger at 1:00 AM, where we asked for help. Thankfully, a young nomad riding a motorbike guided us to our camp, where we arrived at 4:15 AM. We had basically been lost for 15 hours and drove 345 km! After a quick “supper” we went to bed at 5:00 AM. In the meantime though, there were three trucks out looking for us that got lost in the bottom of the basin, and did not return to camp until 7:30 AM.

After a short sleep, we began to make jackets and pack fossils while the Canadian contingent relocated an ankylosaur specimen that the Joint Soviet-Mongolian Paleontological Expedition had abandoned in 1972 or 1973. It was encased in a wooden crate covered by loose boards. Although the skull was missing, the body (MPC-D 100/1359) was in good condition, especially with in situ dermal scutes. We decided to excavate it next year. This specimen has the most complete postcranial skeleton of an ankylosaurid from the Baruungoyot Formation, and seemed to support the possibility that

ankylosaurids practiced digging behavior (Park et al., 2021a). We also found many sauropod footprints beneath an overhanging cliff.

September 15 was our last day in the field. We continued to search for fossils when we were not packing those we had already collected. We found the 1973 Russian-Mongolian quarry for *Tarchia gigantea* (PIN 3142/250). We started our return to Ulaanbaatar the next day. It was also a difficult trip because of many vehicle problems, such as flat tires, overheated engines, leaking radiators, and broken axle, so it was not until 8:00 PM on September 18 that we arrived in Ulaanbaatar.

2008 EXPEDITION

The third KID expedition lasted 40 days between August 15 and September 24, 2008. The field crew included 28 people (16 researchers and twelve Mongolian support staff) (Appendix 1). In addition, we were joined for the whole period by the MBC documentary team (4 people) from Korea to make a film. Because of the vehicle difficulties in 2007, Hwaseong City donated a used six-wheel truck (KAMAZ) to the Paleontological Center. We used two jeeps, six vans, and three trucks for this expedition. Therefore, the expedition was the largest among the five expeditions. Meetings at the Paleontological Center selected Altan Uul, Bugiin Tsav, Hermiin Tsav, and Nemegt for the 2008 field program. The base camp was to be set up at Hermiin Tsav, the primary target.

The Korean contingent plus Currie, Jacobs, Koppelhus, Polcyn, and Sissons arrived in Ulaanbaatar on August 15, after attending a workshop in Hwaseong City in Korea. The next day, the MBC documentary team arrived in Ulaanbaatar. Two more days were spent in Ulaanbaatar applying for visa extensions, preparing supplies and food, and arranging a hot air balloon for aerial cinematography (because cinematic drones were unavailable at that time).

On August 19, two trucks (KAMAZ and ZIL) left before dawn, and the team started with eight vehicles at 8:15 AM. Gas prices had suddenly increased when Russia stopped exporting gasoline, and the Mongolians were seriously concerned about this matter. Consequently, this year an unpaved road was used to go to Arvaykheer, unlike in the past, because it was shorter than the paved road by about 100 km. Furthermore, the paved road was heavily damaged and was in worse shape than the unpaved road. This decision turned out to be very good in that the trip went smoothly except for one flat tire.

We set up the first camp beside the road at 7:30 PM, some 250 km from Ulaanbaatar. We arrived at Arvaykheer the next day at 3:00 PM, but the entire city was experiencing a blackout. After asking around, we found a gas station that pumped gasoline with a generator. The gas station already had many cars lined up for gas, but we filled up all our vehicles. It was 8:00 PM before we set up camp next to the road. We arrived the following morning at Baruunbayan, a small village, on August 21. Alluvial fans, dunes, rivers, and small lakes spread out from the distant mountains, almost looking like environments of the Cretaceous Period. A gas station at Baruunbayan was the last place to fill up the vehicles with gasoline and diesel before entering the southern Gobi. The village was also in a blackout, and we had to use our generator to run a gas pump at the station. One van broke down en route, and we took the road to Bayanlig instead of Bayangobi. It was a slightly larger village, and had a mechanic to fix the van. This village was also in a blackout. We stayed one night near the north slope of Gilbent Mountain. The following day, we realized that the axle bearing of the wagon with the water bowser was broken and left behind with the plan to pick it up later after setting up the base camp at Hermiin Tsav. We finally arrived inside the valley of Hermiin Tsav at 7:00 PM on August 22.

On the first day of the fieldwork, we visited the “Russian ankylosaur” (MPC-D 100/1359). Y.-N. Lee found a small lizard (KID 236), and Lü found a multituberculate skull (KID 238) from the Barrungoyot Formation. On August 24, the prospecting was difficult because of a strong sandstorm. Nevertheless, Jacobs and Polcyn found a *Bagaceratops* skull (KID 262) and excavated it; another *Bagaceratops* skull was found nearby the following day. Bell found an oviraptorid skeleton (KID 251). On August 26, three lizard skulls, *Gobipteryx* eggs, and various isolated dinosaur bones were collected. Sissons found a small theropod (MPC-D 102/114), which turned out to be a significant specimen for confirming the validity of Halszkaraptorinae and their semi-aquatic behavior. Named *Natovenator polydontus*, it had a streamlined body similar to those of modern diving birds with ribs that are angled toward its tail (Lee et al., 2022). This discovery was important because it proved that this new type of non-avian dinosaur could be semi-aquatic.

On August 27, we excavated and made jackets for the

oviraptorid skeleton (KID 251) that Bell had found, which contained some postcranial elements, including the pelvic girdle. Kobayashi found a big therizinosaurid manual claw, which reminded us that we were in the famous place where two giant arms of *Therizinosaurus* (MPC-D 100/15) were found in 1973 (Barsbold, 1976). We split the team the next day to explore Bugiin Tsav and the Nemegt Basin. The Canadian contingent stayed in the Nemegt Basin, and the remainder of the team worked in Bugiin Tsav for three days. Y.-N. Lee found a braincase of cf. *Prenocephale* (MPC-D100/1207), which helped to illusidate the ontogenetic variation of Nemegt pachycephalosaurs (Evans et al., 2018). Jacobs found a turtle bone bed, where many turtles (mainly *Mongoleyms*) were aggregated, suggesting a mass death in a turtle pond. H.-J. Lee collected a complete *Mongoleyms*, including a skull (KID 323).

The Bugiin Tsav camp awoke on August 29 to find that it had rained all night. Ligden told us at noon that we had to return to camp in Hermiin Tsav because the road we had to pass was filling with water; so everyone packed their tents and headed to the base camp. Fortunately, our vehicles passed the river despite two crises, and we safely returned to the base camp around 4:00 PM. The next day, the Canadian contingent returned to camp after having discovered six *Tarbosaurus* sites. Fieldwork in the Nemegt Basin had not been easy either because of rain.

On August 31, we began to excavate the "Russian ankylosaur" (MPC-D 100/1359) by saving the wooden crates of the monolith as historical items. We hardened the skeleton with PVA because the upper layer containing the skeleton was in loose muddy sandstone, while the lower layer was hard sandstone. Bell found an oviraptorid femur and protected it with a plaster jacket (KID 331). The next day, H.-J. Lee found a nest containing eight round eggs. The matrix was too hard to excavate the entire nest, and it took two days to collect three complete eggs.

On September 3, we headed to Altan Uul III and relocated and reopened the holotype quarry of *Deinocheirus*. Nearby, Lü found small theropod bones and made two plaster jackets. The excavation produced one new oviraptorid, *Gobiraptor minutus* (MPC-D 102/111), and three alvarezsaurids (MPC-D 100/203, 206, 207), including a new species, *Nemegtonykus citus* (Lee et al., 2019a, b). The mandibular morphology of *Gobiraptor* is unique among oviraptorids, which may have been an adaptation for hard foodstuffs, such as seeds or bivalves. The number and diversity of alvarezsaurids also suggested that these dinosaurs were more abundant during Nemegt times than the previous fossil had suggested (*Mononykus* was the only known species before).

The film crew had arranged for some aerial photography to be done from a hot air balloon, but it had not shown up on the agreed-upon date. On September 3, we met people on the road looking for our camp. They were in a small, broken-down truck loaded with the hot air balloon. They had repeatedly gotten lost and stuck on the sandy road for six days after leaving Ulaanbaatar. Our meeting them on the road by chance in the middle of the Gobi Desert was truly miraculous. We continued to base camp, initially with them. However, their truck kept causing problems, and because it was getting dark, we had to leave them to spend another night on the road. The following day, the MBC team with Ligden rescued the balloon truck.

September 4 also saw the discovery of another *Bagaceratops* (KID 381) and a lower jaw of *Tarbosaurus* (KID 378) by Sissons and Bell. A rib sticking out from an exposure that Kobayashi had found a few days before turned out to be an ankylosaur (MPC-D 100/1353). The well-preserved *Tarbosaurus* lower jaw was high on a vertical cliff, but led to the discovery of most of the skull and skeleton, and over the next few days during excavation, produced the left maxilla, lacrimal, nasal, parts of the back of the mandible, teeth, and the axis and 3rd cervical vertebra.

In the meantime, the American contingent kept excavating the ankylosaur (MPC-D 100/1353), and soon found the pelvic girdle. The front part of the body was scattered, but the back of the body, including the tail, was articulated *in situ*. The MBC team recorded the whole process of excavation of this animal by using a Jimmy Jib. However, they gave up the idea of doing aerial cinematography using the air balloon because of the strong winds at Hermiin Tsav.

On September 6, Lü returned to Ulaanbaatar with three Mongolian staff. We continued to excavate the ankylosaur (MPC-D 100/1353) and *Tarbosaurus* (KID 378) for two more days. During this period, we collected two more *Bagaceratops* skulls. On September 8, we found both the skull and tail club at the ankylosaur site. The skull was found upside down inside the basket-like ilia, and the tail that was normally stiffened with ossified tendons was bent and broken so that the tail club was lying on top of the ilia. This specimen turned out to be a new species, *Tarchia tumanovae*, and

FIGURE 4. *Tarchia tumanovae* (MPC-D 100/1353) was being excavated at Hermiin Tsav on September 10, 2008.

provided evidence of a dietary change from low-level bulk feeding to selective feeding during Baruungoyot and the Nemegt times. In addition, pathologies on the dorsosacral ribs and the tail provided evidence of the agonistic behavior of this animal (Park et al., 2021b).

The *Tarbosaurus* quarry was finished with the production of eight plaster jackets. MPC-D 100/1353 was mapped, and on September 9 we began to make plaster jackets. The tail and four ribs were separated from the main ankylosaur body the next day and jacketed. We decided to make one jacket for most of the body with the skull (Fig. 4), and the plaster and burlap jacket, weighing approximately two tonnes was ready to move by September 11.

In the meantime, the Canadian contingent had begun to excavate the "Russian ankylosaur" (MPC-D 100/1359). It was too big to include in one jacket, and was separating into three. This ankylosaur includes twelve dorsal vertebrae, ribs, pectoral girdles, forelimbs, pelvic girdles, hindlimbs, and free osteoderms, which presented the most complete postcranial skeleton of an ankylosaurid from the Baruungoyot Formation. Therefore, this articulated postcranial skeleton with in situ dermal scutes provided valuable insight into the postcranial evolution of ankylosaurids (Park et al., 2021a).

We spent the next three days loading the two giant ankylosaur specimens (MPC-D 100/1353, 1359) into the truck. After barely being able to flip the oversized ankylosaur jacket (MPC-D 100/1353), the truck winch dragged it to the top of the hill. We all pushed it up into the truck on wooden boards. At the "Russian ankylosaur" quarry, the heavy truck could not climb the sandy hill after loading the three jackets of MPC-D 100/1359. The winches on the other two trucks eventually pulled it up the hill. From September 14 to 16, the Canadian contingent and Kobayashi worked in Altan Uul, and the remainder of the expedition worked in Bugiin Tsav. The Canadian contingent collected *Saurolophus* skin impressions (KID 416) at Altan Uul II, and three gastralia with many bone fragments at the holotype quarry of *Deinocheirus* at Altan Uul III. Bite marks on two gastralia (MPC-D 100/126) were attributed to *Tarbosaurus* based on the presence of parallel, broadly U-shaped 0.5 mm diameter striae (Bell et al., 2012). At Bugiin Tsav, the American contingent began to make two jackets of aggregated turtles (KID 431). The Canadian contingent came back in a sandstorm to the Bugiin Tsav camp on the evening of September 16.

On September 17, because all supplies, especially food and water, were running out, we decided to return to Ulaanbaatar the next day, which was one day earlier than the original plan. Because we had run out of burlap, we finished making the plaster jackets for the two turtle blocks by cutting up T-shirts. We found a *Tarbosaurus* foot (KID 428) underneath a three meter thick sandstone block but decided to excavate it next year. On September 18, we left for Ulaanbaatar, where we arrived at 2:30 AM on September 20. The MBC documentary "Land of Dinosaurs" was first broadcast in Korea on January 18th, 2009.

2009 EXPEDITION

The fourth KID expedition lasted 38 days, from August 3 to September 9. The field crew comprised 24 people (13 researchers and eleven Mongolian support staff) (Appendix 1). We used two jeeps, three vans, and two trucks (ZIL and KAMAZ) for this expedition. At official meetings in the Paleontological Center, the field sites of Altan Uul, Bugiin Tsav, Nemegt, and Tsagaan Khushuu were picked as the focus for the 2009 expedition. The base camp was set up at Bugiin Tsav, the primary target. The Nemegt Formation at Bugiin Tsav is unlike the other sites because rather than being in canyons, the 80 m thick beds are distributed over a wide area of 8 km^2. The fossils include skeletons of *Gallimimus*, *Nomingia*, *Saurolophus*, and *Tarbosaurus*.

The Korean contingent arrived in Ulaanbaatar on August 3. After checking our field gear at the Paleontological Center on August 4, we returned to the hotel to discover that Graf from the USA was not checked in because nobody had picked him up at the airport. We rushed to the airport and found him in a panic because he had been abandoned for four hours on his first visit to Mongolia. In the afternoon, we went to the eastern lab, where supplies were loaded onto one truck (ZIL). The other truck (KAMAZ) was empty, and its cargo space had been replaced with a giant shipping container. By the next day, the two trucks left in the evening.

On August 6, the rest of the expedition left at 8:30 AM. Basbold was not able to attend this time due to a health problem. We caught up with the two trucks at Arvaykheer that afternoon. However, by the next day the KAMAZ repeatedly stopped every few kilometers because the engine was over-heating. The Mongolian drivers tried to fix a cracked gasket, but the problem was not solved. We got stuck on the road just 50 km south of Arvaykheer. During the disassembly of the engine, the drivers found that the upper part of the right 4^{th} cylinder sleeve was cracked. When they opened the engine bottom and pulled out the piston, Lidgen went to Arvaykheer to get an engine sleeve. He returned with the sleeve much earlier than we expected. On the way back to Arvaykheer, lucky enough, he met a KAMAZ truck driver with an extra sleeve of the same model. Because of the engine problems of the KAMAZ, we spent three days getting parts and fixing the truck. There was nothing for researchers to do because we were on the Mongolian steppe above the metamorphic rocks. On September 10, we moved again, but frustrating enough, the truck soon stopped with an overheated engine. Most of the expedition proceeded to the next village, Baruunbayan, and left the two trucks to make their way with frequent stops to cool down. As expected, there was no way to fix the truck because we could not get the necessary parts in the village. We moved the essential items to set up camp from the KAMAZ to the ZIL truck, and left KAMAZ with Jagaa at Baruunbayan. The four vehicles finally arrived at Bugiin Tsav at 4:00 PM on August 11. It had taken six days to reach the destination, which was four days more than expected. After setting up the base camp, Ligden returned to the Baruunbayan with a ZIL to fix the KAMAZ.

We split into two groups on August 12, the first day of fieldwork. One group visited the *Tarbosaurus* site that we found on the last day of the 2008 expedition. We tried to move the big block covering the *Tarbosaurus* (KID 428) down the hill, but it would not move. We were at Bugiin Tsav, notorious for high summer temperatures, and it was over 40°C with a bit of humidity. We drank much water, so we worried about the shortage of drinking water. The other contingent visited the Hayashibara base camp (Hayashibara Museum of Natural History Expedition, Japan) nearby and got information on fossil occurrences. A few isolated dinosaur footprint casts were found in an outcrop at the west end of the camp. After removing the big block with pry bars and car jacks at the *Tarbosaurus* site the next day, we found a lower hind limb but no more bones. The ZIL and KAMAZ arrived in camp in the afternoon. A severe sandstorm hit the camp at night.

On the morning of August 14, we fixed broken tents and rebuilt the camp. In the afternoon, we investigated an attractive bone bed of *Gallimimus* that we had found on the day we arrived. It included five holes that had been made by

poachers, which were subsequently covered with sand. By sweeping the sand from one of these holes, we found the horizon had 14 theropod trackways, and the skeleton of a *Gallimimus* foot (MPC-D 100F/17). The next day, we continued to uncover the *Gallimimus* track site. We studied the unusual association of dinosaur bones and footprints using taphonomic and sedimentologic data, and concluded that it was hard to prove that there was a direct association between the *Gallimimus* foot and the theropod trackways (Lee et al., 2018).

On August 16, while prospecting in the low hills northwest of Bugiin Tsav, H.-J. Lee and Y.-N. Lee discovered a large quarry that had been poached. The poached quarry was littered with broken bones, large sandstone blocks, empty Chinese superglue and vodka bottles, pieces of plaster, and other junk – clearly the work of unprofessional poachers. The articulated sacral and caudal vertebrae, pelvic girdle, and femur were identified in the sandstone blocks. We returned to the camp as the sun went down. The next day, all the crew went back to see the quarry. Currie told us it could be *Therizinosaurus* because the long neural spines and uniquely shaped pelvic girdle did not belong to *Tarbosaurus*. We all were delighted to think that we might have found *Therizinosaurus*, one of the mysterious dinosaurs of the Gobi. The poached quarry was easy to access by car, and the overburden was not too thick, so the work did not seem too difficult. However, it was judged that a full excavation would take at least ten days.

On August 18, trucks were loaded with excavation equipment, and all team members headed for the site. Except for the big blocks, we started to collect the broken and scattered bones. The cervical, sacral, and caudal vertebrae were collected with the femur, tibia, fibula, and phalanges (Fig. 5). Still, the pectoral girdle and forelimbs were desperately needed to confirm the identification of *Therizinosaurus*. Adams, Jacobs, and Kobayashi arrived at the camp at 11:30 PM that night. The next day was the most memorable of the KID expedition. The quarry was getting more and more interesting. A uniquely shaped pygostyle was found with many gastralia. In addition, more than 1100 rounded and polished gastroliths were recovered in the vicinity of the abdominal ribs. The vertebrae were pneumatic, with highly developed fossae and laminae, similar to those of sauropod dinosaurs. The identity of this dinosaur became more and more curious. At 3:30 PM, Y.-N. Lee finally identified a fused left coracoid and scapula on the block he was working on. It was none other than the scapulocoracoid of *Deinocheirus*. It was clearly not *Therizinosaurus*. He jumped up and shouted. “This is *Deinocheirus*. We found *Deinocheirus*.” Everyone cheered and rushed to see the bone. It was at that moment that we identified the dinosaur that had been a mystery for the past half-century. Y.-N. Lee pulled out Osmólska’s 1970 *Deinocheirus* paper in the evening in camp, and the scapulocoracoid drawings and photographs exactly matched the bones we found.

From August 20 to September 3, the last day in the field, the excavation and jacketing continued to get all bones of *Deinocheirus* from the quarry. Larger blocks were encased in plaster jackets and pulled sideways from the excavation. Further excavation was carried out in the newly exposed regions to reveal several cervical vertebrae, and a left humerus, ulna, and radius. The distal parts of the ulna and radius, and part of the metacarpus were found in the rubble left by the poachers. The left forearm was now complete except for the distal parts of the metacarpals and the phalanges. The poachers probably took the left hand. They probably also had collected the right forelimb and both feet (except for one pedal phalanx), and unfortunately, the skull was also missing. The fact that the axis of the cervical vertebrae was broken suggested that they had found the skull. In addition, the dorsal vertebrae with long neural spines were severely crushed and damaged, probably in the process of pulling out the skull underneath. This illegal activity had occurred after 2002, because Mongolian paper money issued in 2002 was left in the quarry, supposedly by the poachers, along with a bottle of vodka. Mongolians have a tradition of leaving a bottle of liquor and a small donation at Ovoo for safe travel.

Fish vertebrae were found along with gastroliths inside the gastralia. These bones had been corroded by gastric acid, which suggested that *Deinocheirus* ate fish. But over 1100 gastroliths found together suggest that *Deinocheirus* ate plants, too. *Deinocheirus* (MPC-D 100/127) was transported to Ulaanbaatar in 38 large and small plaster jackets and several wooden boxes. During the preparation in Korea, Y.-N. Lee noticed that the characteristics of the femoral head were similar to those of an unidentified specimen (MPC-D 100/128) collected in Altan Uul IV in 2006. This specimen was smaller than the Bugiin Tsav *Deinocheirus*, and included the dorsal and caudal vertebrae, pelvic girdle, femur, and tibia. Its femur had the same characteristics as *Deinocheirus*, which confirmed that it was the same species.

FIGURE 5. *Deinocheirus* (MPC-D 100/127) excavating site at Bugiin Tsav on August 18, 2009.

In June 2011, Pascal Godefroit of the Royal Belgian Institute of Natural Sciences contacted Currie to inform him that a European private collector owned the skull, left hand, and both feet of what might be *Deinocheirus*. These bones had been sold to a Japanese fossil collector, and then resold to a German fossil dealer. Y.-N. Lee, Currie, and Kobayashi visited Belgium to observe the fossils and immediately realized they were the missing parts of MPC-D 100/127. None of these bones had been found in the poached quarry, so there were no overlapping bones. We had found the proximal ones of the left metacarpus, but the European specimen had the distal ends of the same bones. Even the one foot bone that we had recovered from the quarry (a right pedal II-2) was missing from the poached specimen in Belgium. When the specimen was repatriated from Europe, the proximal articular facet of pedal phalanx II-2 that we had found fit perfectly with the distal articular facet of pedal phalanx II-1, and with an impression in matrix that had not been prepared. Finally, the last puzzle piece was put together. The long-standing enigmas of *Deinocheirus* for a half-century had been resolved at last (Lee et al., 2014).

In addition, the bone color and the matrix surrounding bones were the same as those of the bones we had excavated. The elongate skull of *Deinocheirus* had a broad snout like a duck-billed hadrosaur, but also had a large lower jaw and no teeth like an ornithomimid dinosaur. The robust feet of *Deinocheirus* were shaped to support weight instead of running rapidly, and the tips of their claws were blunt, which was a unique shape observed for the first time in theropod dinosaurs. Eventually, these fossils were repatriated to Mongolia on May 1, 2014. Soon after, Y.-N. Lee and Currie visited the Paleontological Center to study the skull.

During the final days of the 2009 expedition, the Canadian contingent visited Altan Uul and Nemegt to collect fossils (including a *Deinocheirus* metatarsus KID 452), and also pinpointed the site of the Polish-Mongolian Paleontological Expedition quarry for the holotype specimen from 1965 (Currie, 2016). They also collected a *Saurolophus* braincase

and crest (KID 476) at Bugiin Tsav.

The American contingent made four jackets of blocks containing theropod trackways and the foot at the *Gallimimus* track site, and made a short visit to Tsagan Khushuu on August 24. The collected fossils include articulated proximal caudal vertebrae of *Barsboldia* (KID 477, Prieto-Márquez, 2011) and a hadrosaur foot (KID 459), as well as natural footprint casts of small (KID 444) and large (KID 445) theropods, a big ornithopod (KID 446), and a big sauropod pes (KID 448) footprints. On September 4, we left for Ulaanbaatar and arrived at 6:30 PM on September 5.

2010 EXPEDITION

The last KID expedition lasted for 43 days between August 18 and October 1. The field crew comprised 27 people (18 researchers and nine Mongolian support staff) (Appendix 1). The Canadian contingent left for the Nemegt Basin on August 19, but most of the expedition did not leave until August 26. Three jeeps, four vans, and two trucks (ZIL and KAMAZ) were used for this expedition. In addition, the SBS documentary team (two people) from Korea joined us for a short period to make a film. Altan Uul, Bugiin Tsav, Guriliin Tsav, Khuree Tsav, Nemegt, and Nogoon Tsav were the planned expedition destinations. The first base camp was set up at Bugiin Tsav and moved to Khuree Tsav later.

As usual, purchase of supplies and loading of field gear took three days in Ulaanbaatar. The two trucks left in advance on August 25, and the rest left on the following day in three jeeps and one van. We met our trucks at Arvaykheer at 1:30 PM and went further south, although the KAMAZ had a little problem. On August 28, we arrived at Bugiin Tsav through Khaichin Uul in the afternoon. The Canadian contingent joined us in the evening with a baby *Gallimimus* (KID 499) that they had collected from the Nemegt Basin. We had to rebuild our camp the next day after it was damaged by strong wind overnight. A few bones were collected in the afternoon near the camp. On August 30, we headed to Guriliin Tsav but did not find good specimens except for isolated *Gallimimus*, *Saurolophus*, *Tarbosaurus*, and turtle bones. The next day, we excavated an oviraptorid pelvic girdle with hind limbs (KID 585). On September 1, Barsbold and Eberth returned to Ulaanbaatar. The next day, we made a reconnaissance at Khuree Tsav, 25 km west of the base camp. Khuree Tsav is a relatively unexplored area compared with other famous localities in the southern Gobi. We found many poached sites with some bones, implying that dinosaurs and turtles are abundant at this site. The two hind legs of the oviraptorosaur (KID 585) were buried vertically in the lower mud layer, suggesting it was mired in death. Unfortunately, the upper body was already weathered in the upper sandstone layer.

On September 4, we tried to reach Nogoon Tsav, where we got lost on the way back to Hermiin Tsav in 2008. The trip was not as bad as the last time, and we found many turtles, ankylosaurid dermal scutes, and sauropod skin impressions (KID 599). A giant sandstorm hit our camp in the evening. It rained the next day, so we spent time cataloging and sorting bones. On September 6, we took a jackhammer with a generator to excavate further at the *Deinocheirus* site (MPC-D 100/127) to see if additional bones might exist, but only found a few fragmentary bones and more gastroliths. Fiorillo, Graf, Jacobs, Lü, and two SBS film crew arrived at the camp in the afternoon. The next day, it kept raining, and a cook (Otgon) returned to Ulaanbaatar because her mother passed away. On September 8, we collected an ankylosaurid humerus (KID 630), an ornithopod pathologic fibula (KID 632), and a few isolated bones in Khuree Tsav.

On September 10, we plastered an oviraptorosaur (KID 585), and the American contingent found natural footprint casts at Guriliin Tsav. A freshwater clam was found on the bottom of one ornithopod footprint. Several oviraptorid nests were found at Bugiin Tsav, which might be the first discovery of a colonial nesting ground of oviraptorids (KID 652). We excavated the site the next day, but the clutches were incomplete, so we only collected eggshells. The excavation of a small complete theropod (KID 643) and a sauropod (KID 650) continued in Bugiin Tsav on September 12. The sauropod consisted of giant ilia with six sacral vertebrae. The American contingent visited Khaichin Uul and collected dinosaur eggshells, where the Eocene beds unconformably overlie the Cretaceous Nemegt Formation.

An exciting site was found in the afternoon of September 13 at Khuree Tsav, where articulated distal caudal vertebrae stuck out on a low hill. They continued to the inside of the bed. A pelvis was soon exposed by excavation, followed by the dorsal vertebrae. Even though we were all excited, we had to be careful because the matrix was soft, and the bones were fragile. The skull curved backward, with the neck bent over the dorsal vertebrae. It was a juvenile *Tarbosaurus* (KID 675). Because it was getting dark, we returned to the camp

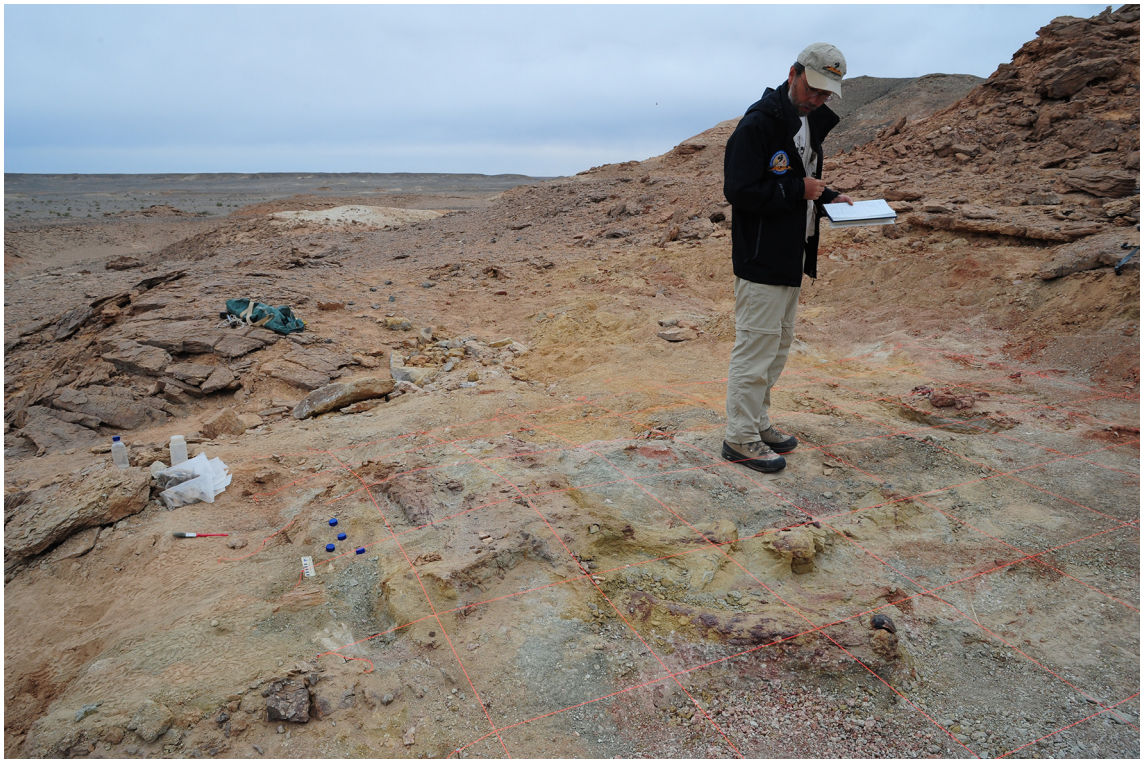

FIGURE 6. Mapping a juvenile *Tarbosaurus* (KID 675) at Khuree Tsav on September 20, 2010.

and discussed the specimen and moving the camp. However, before moving the camp to Khuree Tsav, we had to finish a big sauropod. While the Canadian contingent excavated it, the rest of the crew packed all collections on September 14. The Canadian contingent, Fiorillo, and two SBS producers left for Ulaanbaatar the next day. We finished closing the oversized jacket of the sauropod.

On September 16, we loaded the oversized sauropod jacket into the truck with 20 other plaster jackets and seven sample boxes. In the afternoon, two jeeps, three vans, and two trucks headed to Khuree Tsav and camped near the *Tarbosaurus* site. The next day, the American contingent returned to Bugiin Tsav and found twenty distal caudal vertebrae of *Barsboldia* (KID 477). The *Tarbosaurus* femur was inside a large concretion, and a well-preserved pubis was newly exposed. On September 18, we found another femur, pubis, the 3rd metatarsal, and phalanges. The next day, we found scattered gastralia and teeth in the dentary. We prepared the grid for mapping the next day. In the following two days, we made five jackets for the tail, limb bones, and isolated blocks except for the main body (Fig. 6).

On September 22, the skeleton that needed to be jacketed was cut down to $2 \times 1.5 \times 0.5$ m. Although the thick sandstone underneath the bone layer is too hard to dig out, we undercut the specimen as far as possible. After the jacket was completed (we had a shortage of burlap), we tried to flip it with a truck winch. The 500 kg jacket was slowly lifted and moved, but the center part had not separated from the sandstone layer below. The collapsed center was filled with plaster and sand and reinforced with pieces of wood. The skull part was secured with a separate jacket. This *Tarbosaurus* gave us a grand finale of five years of expeditions. Unfortunately, the specimens collected from the 2010 expedition have not been shipped to Korea due to new Mongolian custom regulations. They will be prepared and studied soon.

DISCUSSION

The greatest challenge for the KID expedition was the Russian military trucks, which were too old and frequently broke down. As a result, the exploration period was often shortened due to delays. If modern and sturdy 4-wheel drive trucks are used in the future, such problems are expected to decrease dramatically. This is also becoming less problematic

as the road system continues to be improved.

All the famous fossil localities that we visited had already been poached, and showed the magnitude of illegal activities. Although poaching has decreased somewhat due to the crackdown by the Mongolian government, it is not easy to manage such a vast area as the Gobi where even nomadic people are widely dispersed. Poachers often take only valuable parts of the skeleton, such as skulls, teeth or claws, and many large elements are left behind (or even destroyed) because they are too bulky. Therefore, we sometimes made astonishing discoveries by looking carefully at poached sites. This was the case with *Deinocheirus*. Due to continuous exploration and excavation since 1923, it is reasonable to say that there are almost no places in famous fossil sites where people have not been. Therefore, exploring unknown localities, even though small and unnamed, can be a way to find untouched fossil sites. Evidently, there are still many unexplored Cretaceous strata in the Gobi, such as Ukhaa Tolgod.

Although dinosaur footprints in the Gobi were relatively late to be discovered (Currie et al., 2003), they are now commonly found in many localities. They are found as impressions on bedding planes, but are more often as natural casts. These footprints are often preserved with sliding marks in three dimensions, so research on these footprint casts will continue to reveal information on how the animals were moving and interacting. Although many expeditions have visited the Gobi over the past 100 years, new fossils continue to be discovered every time. Undoubtedly the Gobi will always remain one of the most important areas for dinosaur fossils in the world.

CONCLUSION

After five years of KID expeditions, 267 plaster jackets and 125 boxes of specimens were transported to the Paleontological Center in Ulaanbaatar. Except for the 2010 collection, the specimens were then shipped to Hwaseong City, Korea, for preparation and research. The collection was cataloged as 694 specimens, including a variety of fossil assemblages such as plants, fishes, turtles, lizards, crocodyliforms, dinosaurs, birds, and mammals. In addition to bones, there were footprints, skin impressions, and eggs. These fossils prove again that the Gobi is the Mecca of Vertebrate Paleontology. Six people prepared all specimens shipped to Korea for six years at the Hwaseong dinosaur visitor center laboratory, and then all fossils were repatriated to Mongolia in April 2017.

All participating researchers of the KID expedition have been working on specimens for scientific papers together. Eighteen important paleontological papers have been published so far, and more articles are expected to be published soon. Besides its outstanding scientific achievement, the KID expedition promoted international cooperation, built collections for research, and fostered education by providing graduate students with opportunities to study valuable specimens. It was also a critical project for the museum of Hwaseong City, which is now constructing a “Dinosaur Science Center” at the dinosaur egg site that aims to be the top dinosaur research institute in Korea. The authorities of Hwaseong City recognize with confidence that this center associated with the KID expeditions will enhance the cultural attraction and promote ecotourism in Hwaseong City.

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APPENDIX 1. List of field crew (alphabetic last name order of researchers)

2006	2007	2008	2009	2010
Rinchen Barsbold	Rinchen Barsbold	Rinchen Barsbold	Thomas L. Adams	Victoria M. Arbour
Philip J. Currie	Philip J. Currie	Phil Bell	Philip J. Currie	Rinchen Barsbold
Anthony R. Fiorillo	David A. Eberth	Philip J. Currie	David A. Eberth	Philip J. Currie
Bayasgaa Ganzorig	Bayasgaa Ganzorig	Louis L. Jacobs	Bayasgaa Ganzorig	David A. Eberth
Louis L. Jacobs	Namsoo Kim	Bayasgaa Ganzorig	John Graf	Anthony R. Fiorillo
Namsoo Kim	Yoshitsugu Kobayashi	Namsoo Kim	Louis L. Jacobs	Bayasgaa Ganzorig
Yoshitsugu Kobayashi	Eva B. Koppelhus	Yoshitsugu Kobayashi	Namsoo Kim	John Graf
Eva B. Koppelhus	Martin Kundrát	Eva B. Koppelhus	Yoshitsugu Kobayashi	Louis L. Jacobs
Yuong-Nam Lee	Yuong-Nam Lee	Hang-Jae Lee	Eva B. Koppelhus	Namsoo Kim
B. Lkhaasuren	B. Lkhaasuren	Yuong-Nam Lee	Derek W. Larson	Yoshitsugu Kobayashi
Junchang Lü	Buuvei Mainbayar	B. Lkhaasuren	Hang-Jae Lee	Eva B. Koppelhus
Kent Newman	Octavio Mateus	Junchang Lü	Yuong-Nam Lee	Hang-Jae Lee
Michael J. Ryan	Michael J. Ryan	Michael J. Polcyn	B. Lkhaasuren	Yuong-Nam Lee
Kyo-Young Song	Kyo-Young Song	Michael J. Ryan	Ligden Barsbold	Allan Lindoe
Dale A. Winkler	François Therrien	Robin Sissions	Babi	B. Lkhaasuren
Ligden Barsbold	Yosuke Nisida	Kyo-Young Song	Turuu	Junchang Lü
Tsatsral	Dala K. Zelenitsky	Ligden Barsbold	Jagaa	Ariana Paulina-Carabajal
Batugii	Ligden Barsbold	Zorigoo	Darcha	W. Scott Persons IV
Batchuluun	Batugii	Turuu	Mungh	Ligden Barsbold
Gomvold	Divide	Jagaa	Baska	Babi
Chuluunjav	Darcha	Darcha	Mindae	Jagaa
Otogondauur	Chegai	Batochia	Otgon	Darcha
Narantsetseg	Chenbur	Bayaraa		Ji
Otgon	Mungrut	Amgalan		Mungh
	Batbagir	Mungh		Mindae
	Inghe	Baska		Otgon
	Chumong	Otgon		Nara
		Chuka		

APPENDIX 2. List of KID collections mentioned in the text

KID #	Date	Identification	Elements	Locality	Formation	GPS (North)	GPS (East)
KID022	2006-09-12	*Tarbosaurus*	pelvic girdle with proximal caudals	Altan Uul IV	Nemegt	43°36.113'	100°27.274'
KID069	2006-09-21	*Tarbosaurus*	postcranial skeleton with gastralia and stomach content	Altan Uul III	Nemegt	43°35.586'	100°29.760'
KID101	2006-09-25	ornithomimid	a complete skeleton	Ulaan Khushuu	Nemegt	43°30.162'	100°29.373'
KID106	2007-08-21	sauropod	postcranial skeleton without a skull	Shine Us Khudag	Bayanshiree	44°21.515'	109°21.168'
KID113	2007-08-22	therizinosaur	femur	Shine Us Khudag	Bayanshiree	44°20.249'	109°19.224'
KID139	2007-08-28	microsite	"various dinosaur teeth, scutes, claws"	Shine Us Khudag	Bayanshiree	44°16.307'	109°54.503'
KID148	2007-08-28	*Yamaceratops*	postcranial skeleton	Shine Us Khudag	Javkhlant	44°22.648'	109°18.785'
KID150	2007-08-28	*Yamaceratops*	postcranial skeleton	Shine Us Khudag	Javkhlant	44°22.706'	109°19.313'
KID155	2007-08-29	ankylosaur	pelvic girdle with hind limbs	Shine Us Khudag	Bayanshiree	44°21.870'	109°21.450'
KID196	2007-09-10	*Bagaceratops*	skeleton	Hermiin Tsav	Baruungoyot	43°29.636'	99°49.677'
KID202	2007-09-12	an egg nest	dinosaur eggs with embryos	Hermiin Tsav	Nemegt	43°27.990'	99°53.851'
KID205	2007-09-12	crocodyliform	skull	Hermiin Tsav	Nemegt	43°29.582'	99°51.503'
KID206	2007-09-12	*Tarbosaurus*	maxilla	Hermiin Tsav	Nemegt	43°29.571'	99°51.489'
KID236	2008-08-23	lizard	articulated pelvic girdle and hind limbs	Hermiin Tsav	Baruungoyot	43°28.753'	99°50.831'
KID238	2008-08-23	multituberculata	skull and cervicals	Hermiin Tsav	Baruungoyot	43°28.121'	99°50.870'
KID251	2008-08-24	oviraptorid	postcranial skeleton	Hermiin Tsav	Baruungoyot	43°28.037'	99°50.849'
KID262	2008-08-25	*Bagaceratops*	a partial skull	Hermiin Tsav	Baruungoyot	43°28.484'	99°50.228'
KID323	2008-08-30	*Mongoleyms*	skull and shell	Bugiin Tsav	Nemegt	43°50.365'	100°00.903'
KID331	2008-08-31	oviraptorid	femur	Hermiin Tsav	Nemegt	43°27.903'	99°50.039'
KID378	2008-09-04	*Tarbosaurus*	a partial skull with cervicals	Hermiin Tsav	Nemegt	43°27.917'	99°50.268'
KID381	2008-09-04	*Bagaceratops*	a partial skull	Hermiin Tsav	Baruungoyot	43°28.094'	99°50.207'
KID416	2008-09-16	*Saurolophus*	skin impressions	Altan Uul II	Nemegt	43°36.191'	100°33.663'
KID428	2008-09-17	*Tarbosaurus*	a lower hind leg with foot	Bugiin Tsav	Nemegt	43°49.665'	99°58.596'
KID431	2008-09-18	*Mongoleyms*	turtle aggregation	Bugiin Tsav	Nemegt	43°50.365'	100°00.948'
KID444	2009-08-14	theropod	footprint cast	Bugiin Tsav	Nemegt	43°50.037'	100°0.624'
KID445	2009-08-15	*Tarbosaurus?*	footprint cast	Bugiin Tsav	Nemegt	43°50.037'	100°0.624'
KID446	2009-08-15	*Saurolophus?*	footprint cast	Bugiin Tsav	Nemegt	43°49.514'	99°58.553'
KID448	2009-08-18	sauropod	pes footprint cast	Bugiin Tsav	Nemegt	43°53.286'	99°58.174'
KID459	2009-08-24	therizinosaur	foot	Tsagaan Khushuu	Nemegt	43°28.838'	100°21.139'
KID476	2009-09-01	*Saurolophus*	braincase and crest	Bugiin Tsav	Nemegt	43°51.983'	100°00.582'
KID477	2009-09-02	*Barsboldia*	articulated caudals	Bugiin Tsav	Nemegt	43°52.638'	99°58.901'
KID499	2010-08-23	Galimimus	juvenile skeleton	Nemegt	Nemegt	43°32.609'	101°01.927'
KID585	2010-08-29	oviraptorid	pelvic girdle with hind limbs	Bugiin Tsav	Nemegt	43°50.381'	100°02.258'
KID599	2010-09-04	sauropod	skin impression	Nogoon Tsav	Nemegt	43°37.798'	99°10.454'
KID630	2010-09-08	ankylosaurid	humerus	Khuree Tsav	Nemegt	43°44.230'	99°42.323'
KID632	2010-09-08	hadrosaurid	pathologic fibula	Khuree Tsav	Nemegt	43°43.985'	99°41.445'
KID643	2010-09-09	theropd	skeleton	Bugiin Tsav	Nemegt	43°52.400'	100°1.121'
KID650	2010-09-10	sauropod	pelvic girdle	Bugiin Tsav	Nemegt	43°52.257'	100°00.592
KID652	2010-09-12	oviraptorosaur	eggs in nest	Bugiin Tsav	Nemegt	43°50.933'	100°03.169'
KID675	2010-09-13	*Tarbosaurus*	skeleton	Khuree Tsav	Nemegt	43°46.145'	99°41.264'