Oxfordian (Jurassic) mayaitid (ammonite) dispersal in the Tibetan Himalaya as the first signal of the establishment of the Indo-Austral subrealm

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Abstract New fossil collections in the Lanongla area, Tibetan Himalaya enable the establishment of the Upper Jurassic ammonoid succession. Middle Oxfordian ammonite fauna is characterized by endemic epimayaitids with a marine deepening event, suggesting a high stand of sea level in the Tibetan Himalaya. Distribution of mayaitids around the Eastern Gondwana can be regarded as the first signal of the Indo-Austral Subrealm that was progressively established during the Late Jurassic and Early Cretaceous times.

Keywords: Jurassic, Oxfordian, ammonites, Tibetan Himalaya, Indo-Austral Subrealm.

The Oxfordian ammonites in the Tibetan Himalaya were first reported by Huang in his M.S. thesis[1]. After making an examination on the illustrations of Huang’s thesis in 1981, Westermann et al. noted that diverse Mayaitinae occurred below Macrocephalitinae as Huang said[1]. In 1985 he took a trip to the Lanongla area along the Chinese-Nepal Highway to investigate the sections where Huang had sampled before. However, they failed to duplicate Oxfordian ammonites, and concluded that “A paraconformity with extensive hiatus (Middle Callovian-Lower Kimmeridgian) is therefore present between the two shale units in the Spiti Shales…”[11]. In 1996, Callomon paid a visit to the author in Beijing and examined the collections, confirming that Huang’s identification on mayaitids was reliable but their horizon remained to be further clarified.

With the financial supports from the NNSF of China and the NGS the author carried out field work in the Lanongla area, the Tibetan Himalaya from 1997 to 2001 (Fig. 1). New collections bed by bed enable the establishment of the Jurassic ammonoid succession, ranging from Rhaetian to Tithonian[2-5]; the fossil horizons in the Huang’s collection are partly clarified in the light of the current study. The purpose of this note is to report mayaitid in the Lanongla sections and to explain its paleobiogeographic significance.

1 Biostratigraphy

Lithologic descriptions of the Jurassic in the working area are demonstrated in Table 1. Earlier studies in the area were carried out repeatedly in the Lanongla section by various authors as this section was easily accessible and fossiliferous. However, their work had also raised a confusion in lithostratigraphic classifications[1,6-8], some of which were regarded as the duplication of existing names, such as the Spiti Shale, the Lanongla, Menbu and Xiumo Formations[1,9]. The Oxfordian rocks outcropping in the area are found in small, branch gills of the Da-Seju valley (It means big muddy valley in Tibetan language), namely as Lanongla section A and section B,
respectively.

Table 1. Lithologic units and stratigraphic correlation of the Jurassic in the area

<table>
<thead>
<tr>
<th>Period</th>
<th>This study</th>
<th>Xue et al. [9]</th>
<th>Wan et al. [10]</th>
<th>Wenewardt et al. [8]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Cretaceous</td>
<td>Not investigated</td>
<td>Guan-Pin I</td>
<td>Guan-Pin II</td>
<td>Not investigated</td>
</tr>
<tr>
<td>Lower Cretaceous</td>
<td>Spath Shales</td>
<td>Xian-Pin</td>
<td>Neimeng-Pin</td>
<td>Neimeng-Pin</td>
</tr>
<tr>
<td>Jurassic</td>
<td>Malaik</td>
<td>Menkaudun Fm</td>
<td>Menkaudun Fm</td>
<td>Middle Jurassic</td>
</tr>
<tr>
<td>Lower</td>
<td>Papagi Fm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper</td>
<td>Papagi Fm</td>
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<td></td>
</tr>
<tr>
<td>Upper Triassic</td>
<td>Geno-Pin</td>
<td>Zhann-Pin</td>
<td>Zhann-Pin</td>
<td>Upper Triassic</td>
</tr>
</tbody>
</table>

In section A Upper Bathonian and Lower Callovian ammonites are sampled from the Ferruginous Oolite Fm and the lower part of the Menkaudun Fm (Fig. 2, sections A, C). A hiatus, embracing Middle Callovian to Lower Oxfordian, is likely present in the section because neither Lower Callovian nor Middle Oxfordian ammonite has been found up to now. The Lower Callovian is topped by the yellow-greenish, argillaceous siltstones of 10 m thickness in which fossils are scarce.

Fig. 2. Biostratigraphy of the Lanoglia sections. Section A shows the strata ranging from Bajocian to Lower Callovian; section B shows the strata ranging from Oxfordian to Tithonian; section C shows the horizons of the Upper Bathonian and Lower Callovian ammonites in section A. Fossil occurrences are marked on the photo. The black circled number: 1. Belemnosites galoi 2. Ulytigites 3. Haplolithoceras assemblages.

Two dhosaitid specimens were sampled from the beds just above the siltstones in the section. One of them (Fig. 3, 1) fairly resembles *Dhosaites otoitoides* Spath in distant, acute, bifurcated ribbing and relative evolution, illustrated by Spath. The second one (Fig. 3, 2, 3, 7) is associated with a fragment of mayaitid on one slab. It is well comparable with *Dhosaites primus* Spath by involustion and closer costation. These two species were first found in the Dhosa Oolite Formations in Kachch, West India. However, as has been recognized by Spath himself, there still exist transitional forms between *Dhosaites otoitoides* and *Dhosaites primus*. The mayaitid specimens with *Dhosaites cf. primus* are only fragments, exhibiting compressed shell, involustion and dense-ribbing; its feature appears to be typical to mayaitid
Fig. 3. Explanation of the illustration. 1. **Dinocrinus cf. acutus** Spath, L701 (section A; the Menkedan Fm), almost a complete body chamber whorl. 2, 3 and 7. **Dinocrinus cf. primus** Spath, L702 (section A; the Menkedan Fm) (2, lateral view; 3, internal view of the specimen which is associated with a fragment of matrix on the right; 7, ventral view). 4. Mayaioid, L703 (section A; the Menkedan Fm); a fragment. 5, 6. **Eponagurus fulicoides** Spath, LSN2-1 (section B; the Menkedan Fm) (5, lateral view; 6, ventral view). 8, 9. **Eponagurus aff. fuscus** Spath, LSN2-2, 3 (section B; the Menkedan Fm) (lateral views with the body chamber). All figured specimens are deposited in the collection of Earth Sciences, Claude-Bernard University, Lyon, France.
Section B is located 800 m west of section A, and the pre-Oxfordian strata are mostly covered (Fig. 2, section B). It seems to the author that this section should be very close to section B that has been mentioned in the earlier work\(^{13}\). The Oxfordian shales are about 6–9 m in thickness, which are remarkably distinguished by dark color from the overlying and underlying beds, but mayaitid fossils are only preserved in concretions occurring on the top of the shales (Fig. 2, section B and photo). The specimens (Fig. 3, 5, 6, 8, 9) have been assigned to *Epinayaites falcoidei* Späth\(^{10}\) and to *Epinayaites al-furicus badiensis* (Späth)\(^{11}\), respectively. *Epinayaites falcoidei* was first found in the Kandote sandstone formation of Kachch, West India, dated the Middle Oxfordian\(^{16}\). This epimayaitid assemblage is well comparable with the Middle Oxfordian assemblage in the Nupra Formation of Thakkhol, Nepal\(^{11}\).

Owing to the failure to confine the Oxfordian deposition Westermann et al. put forward an interpretation that “the pre-Kimmeridgian hiatus documented for our locality 13 (e.g. the Lanangla section) in Central Himalaya of Tibet may extend to other areas, with the higher Callovian and Oxfordian frequently done in the Lower Spiti Shales...”. Some of macrocephalitids are accommodated into *Graviceras* by them\(^{11}\), a genus is unclear in affinities and age\(^{12}\). But their hypothesis is not supported by the data presented in this paper. Specimens which were referred to *Graviceras gcuoci* by them\(^{11}\) are fairly rich and associated with other Lower Callovian forms in section A (Fig. 2, section C), but *Graviceras gcuoci* has been revised as *Macrocephalites gcuoci*\(^{13,15}\). A poorly preserved specimen (probably yielded very near the present section B) was referred to as "*Graviceras*"\(^{11}\); but it is more or less similar to mayaitid rather than to macrocephalitid. Cariou et al.\(^{15,14}\) and Enay et al.\(^{18}\) have made intensive discussions on *Graviceras*, indicating that *Macrocephalites* cf. *wuageni* Uhlig has been erroneously referred to as *Graviceras* by Westermann\(^{11}\).

### 2 Faunal distribution and sea-level changes

As has been noted above, the early Callovian ammonites in the Lanangla area are characterized by a faunal mixture between European and endemic forms. Most species of *Bullatimorphites*, *Jeanniericeras* and *Hecticoceras* in Fig. 2, section C were first known in Germany and France, but endemic *Macrocephalites gcuoci* dominates the early Callovian fauna. Some of macrocephalitids in the fauna are well comparable with those of Sula Islands and Papua-New Guinea\(^{16}\). Furthermore, *Neuqueniceras*, a genus typical of Pacific domain was also found in this fauna (Fig. 4). Mayaitids have been extensively reviewed\(^{15,18}\), known in Eastern Africa, Malagasy, Kachch, Zanskar, Nepal (Thakkhol), Sula Islands and Papua-New Guinea, Tibet of China (in this note) and New Zealand\(^{16}\). Previous report of *Epinayaites* in Antarctic Peninsula has been revised lately\(^{20,21}\).

![Fig. 4. Mayaitid distribution around the eastern Gondwanan margin. Base map adapted from Hollam\(^{19}\) and Enay et al.\(^{18}\).](image-url)

Following the Middle Oxfordian mayaitids the numerous endemic forms, such as Kimmeridgian *Australibuchia* (Bivalvia)\(^{22}\), *Sulaites*, Tithonian *Belemnopsis galoi* (Boehm) (belemnite)\(^{21}\), *Uligites*, *Haplophycoceras* and *Blanfordiceras*, either dominated or exclusively appeared in greater richness and low diversity in the Tibetan Himalaya. It is suggested that a new unit, namely peri-Gondwanan Indo-Austral Subrealm should be employed to accommodate these endemic faunas\(^{15,18}\). The new data from the Tibetan Himalaya are in a position to support the hypothesis, and the appearance of mayaitids in the Tibetan Himalaya might be the first signal of the establishment of the biogeographic Subrealm recognized newly.

Ammonite dispersal is influenced by sea-level
changes to a large extent because marked sea-level rise improved marine connections between previously semi-isolated areas; likewise, strong faunal provincialism established in the course of eustatic fall, which caused the regression of seas from continental platforms. The employment of combination of sedimentary succession of shallowing and deepening cycles and intercontinental correlation with regression and transgression enables the establishment of the episodes of sea-level changes. In the Lanongla section Upper Bathonian sediments are passing up into the Lower Callovian with a thinning and fining upward succession (Fig. 2, section C). It is noteworthy that the Lower Callovian black shales and siltstones mark a distinct cycle, probably capped by an erosion surface in section A. In section B a deepening sequence of the Middle Oxfordian is well recognized, consisting of black shale and siltstone, well distinguishable from the underlying and overlying beds by dark color (Fig. 2, section B and photo), topped by a layer of large concretions yielding epimayaitids. Strata above the ammonite-bearing beds are composed of yellow-greenish sandstone indicative of a relatively shallow environment in which ammonites are barren, but *Hibolites* is fairly abundant. In the two sections there is a hiatus between the Middle Oxfordian and overlying beds in which two Upper Kimmeridgian bachiid zones, the *Sptiensis* and *Concentrica*, have been recognized.

At Ler of Kachch, India, the Dhosa Oolite Member shows characteristics of a highly condensed unit, reworked concretions, extremely low rates of net sedimentation evidenced by ammonites, indicating a transgressive condensation; this Member is topped by a ferruginous crust with abundant ammonites; they are most likely dated the upper Oxfordian. In Thakkhola, Nepal, a hiatus of 8 Ma between the Early Callovian and the Middle Oxfordian has been proven, followed by a transgression with *Epimayaites* dispersa. Widespread presence of the Middle Oxfordian ammonites in the Spiti Shales in the Himalaya have been recognized before. It is assumed that the Middle Oxfordian marine deepening event or transgression is characteristically marked by the dispersal of epimayaitid in black shales. In general, the basal deposits of marine deepening events within the basal settings are characteristic; black shales signifying bottom-water anoxia and transgressive events might be marked by a geographic expansion of the area of anoxia. This local deepening event has widely been correlated with the precision of stage by the *Epimayaites* fauna, which seems helpful in identifying a local response to eustatic signal in the Tibetan Himalayas. Recently, Westermann argues that the Austral Subrealm did not appear until mid-Cretaceous, and Jurassic Himalayan ammonoid faunas belong to his Southwestern Pacific Province. As has been shown above, the affinity in the pre-Oxfordian of the Tibet Himalaya is apparently close to Mediterranean Province, but since mid-Oxfordian the distribution of endemic forms spreads to all Eastern Gondwana, the Indo-Austral Subrealm can be well defined.

The initiation of separation of the eastern and western components of Gondwana has been documented by a series of ocean-floor magnetic anomalies. The distribution of mayaitids around Eastern Gondwana would be the response to the early phase of Pangaea breakup; and the depression between Africa and Antarctic-Indian continents may have enabled the establishment of a direct marine link between north and south for the first time. It is suggested that the Indo-Austral can be corresponding to Boreal realm during late Upper Jurassic times, and it is postulated that latitudes should be a prime factor controlling the faunal distribution. However, it is mostly noteworthy that the dispersals of mayaitids and succeeding endemic taxa such as *Uhtigites*, *Haplophylloiceras*, *Blanfordiceras* are known to spread mainly around the Eastern Gondwana rather than a global dispersal pattern; in spite of the fact that the Oxfordian seas achieved a maximum extent in the Jurassic over the world. Taking into account the sea-level changes during these times, the likeliest cause of the provinciality of the Indo-Austral biogeographic region, progressively better established since middle Oxfordian, involves the initial break up of the Indian Ocean which may have acted as an effective barrier preventing Western-Tethyan ammonites' dispersal to the Southeast Pacific domain, the Indo-Austral Subrealm.

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