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## **ROUTE 1: SANCHA AND WA' ERGANG, HUNAN PROVINCE**

# **THE SANCHA-WANGJIASHAN SECTION, HUNAN PROVINCE, CHINA: OCCURRENCE OF SYNGENETIC Fe-Ni-Mo ORE LAYERS NEAR THE BASE OF THE LOWERMOST CAMBRIAN NIUTITANG FORMATION**

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## **INTRODUCTION**

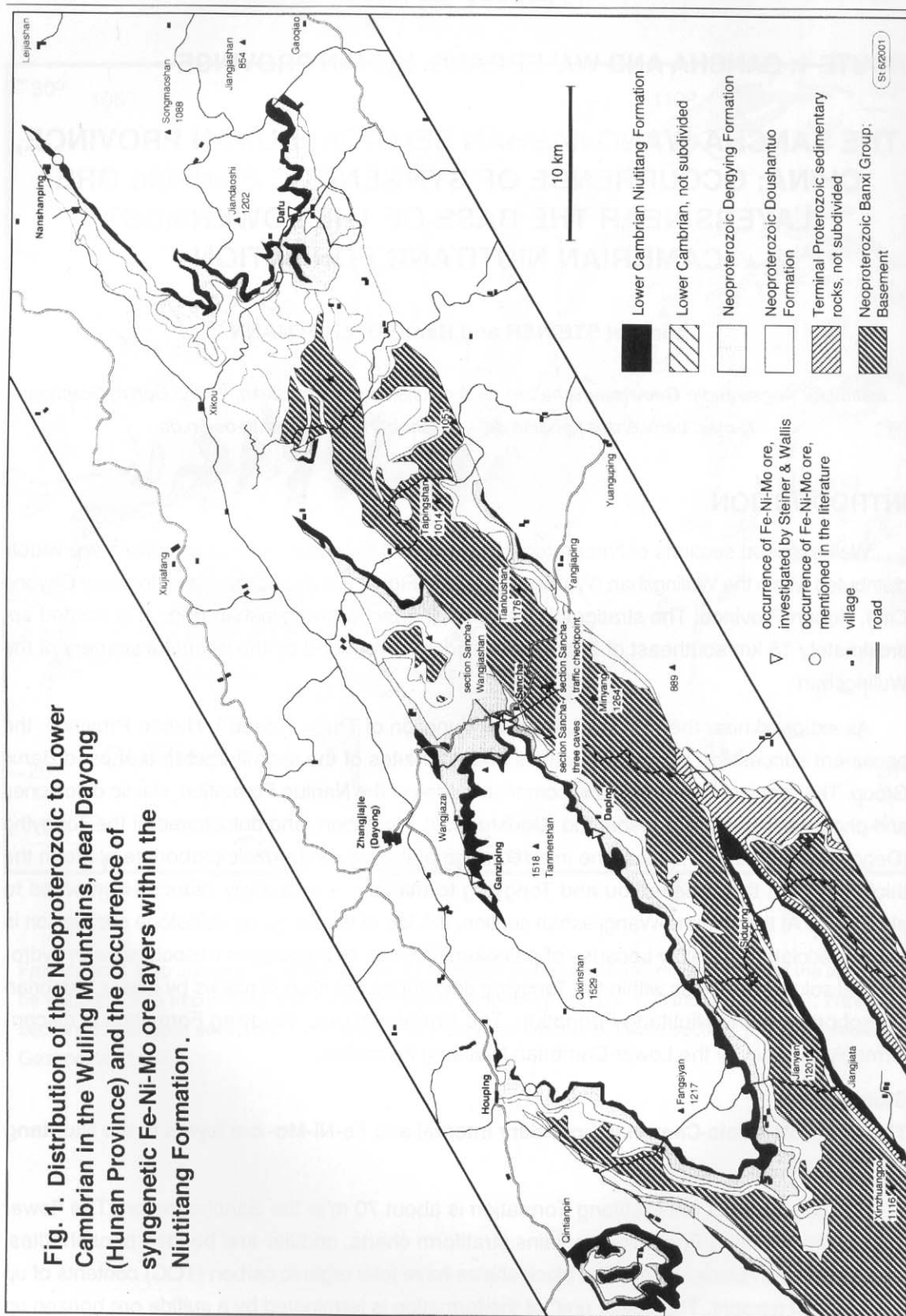
Well-exposed sections of Neoproterozoic to Middle Cambrian rock successions are widely distributed within the Wulingshan (Wuling Mountains; Fig. 1), south of Zhangjiajie (formerly Dayong City), Hunan Province. The stratigraphic section at Sancha-Wangjiashan (Fig. 2) is located approximately 15 km southeast of Zhangjiajie, and is surrounded by the beautiful scenery of the Wulingshan.

As exposed near the village of Sancha ("Junction of Three Roads"), Hunan Province, the basement succession comprises schists and quartzites of the slightly metamorphosed Banxi Group. The terminal Neoproterozoic comprises tillites of the Nantuo Formation, clastic dolostones and phosphorites of the Touthantuo (Doushantou) Formation, and dolostones of the Tongying (Dengying) Formation. Near to the inferred edge of the Neoproterozoic carbonate platform the thicknesses of the Touthantou and Tongying formations are strongly reduced compared to elsewhere. At the Sancha-Wangjiashan section, the top of the Tongying dolostone succession is partly brecciated, possibly because of paleokarstification or brecciation associated with hydrothermal solution. Cavities within the Tongying dolostones are filled in places by Lower Cambrian phosphorites of the Niutitang Formation. The Neoproterozoic Tongying Formation is disconformably overlain by the Lower Cambrian Niutitang Formation.

### **Stop 1**

#### **The Neoproterozoic-Cambrian boundary interval and Fe-Ni-Mo- ore layers in the Niutitang Formation**

The thickness of the Niutitang Formation is about 70 m in the Sancha region. The "lower unit" of the Niutitang Formation contains stratiform cherts, nodular and bedded phosphorites, and organic-rich black shales. The black shales have total organic carbon (TOC) contents of up to 15 weight percent. The "lower unit" of the formation is terminated by a sulfide ore horizon up



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AT SANCHA, HUNAN

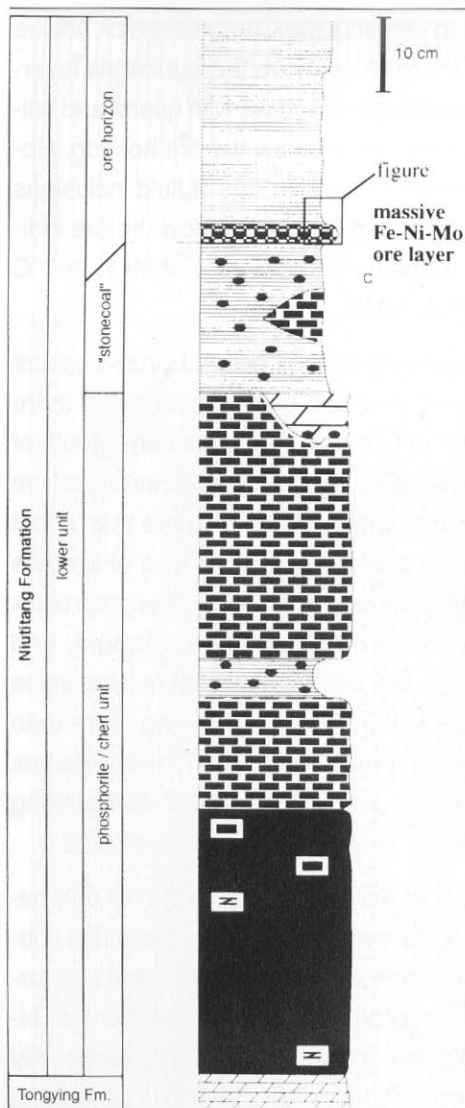


Fig. 2. Fieldtrip Stop, the Sancha-Wangjiashan section.

to 1 m thick. This ore horizon includes a massive Fe-Ni-Mo debris ore layer (Fig. 3) and numerous millimeter- and submillimeter-scale black shale layers with ore debris. The ore horizon is overlain by pyritic black shales and black shale-dark siltstone interbeds of the upper unit of the Niutitang Formation (Fig. 4).

The sediment-hosted Fe-Ni-Mo ore layer has been known to local geologists for at least 30 years (Fan *et al.*, 1973) and was mined periodically by farmers until the mid-1990s. The ore can be in principle classified as of SEDEX-type; however it shows an unusual enrichment pattern. The enrichment factor of this sedimentary ore type ranges from 100 to more than 10000 that of post-Archean shale composite (PAAS) for such trace elements as Mo, Ni, As, Sb, and Ag. Geological, geochemical, and mineralogical reinvestigations of the ore (Coveney *et al.*, 1992; Murowchick *et al.*, 1994; Lott *et al.*, 1999; Steiner *et al.*, 2001) indicate a syngenetic origin related to an Early Cambrian submarine-hydrothermal system. This system is interpreted as comparable to modern hydrothermal vents. The distribution of the ore is closely related to local syntectonic displacements (Fig. 5), which also caused strongly varying thicknesses of the lithologies of the basal unit of the Niutitang Formation. Differences in paleorelief were mainly compensated for by different thicknesses in chert of the "lower unit" (Figs. 5, 6). Minor faults that displace the Proterozoic basement and the basal Cambrian are present in the Sancha area, but they have not been ob-



Fig. 3. Fe-Ni-Mo ore sample .

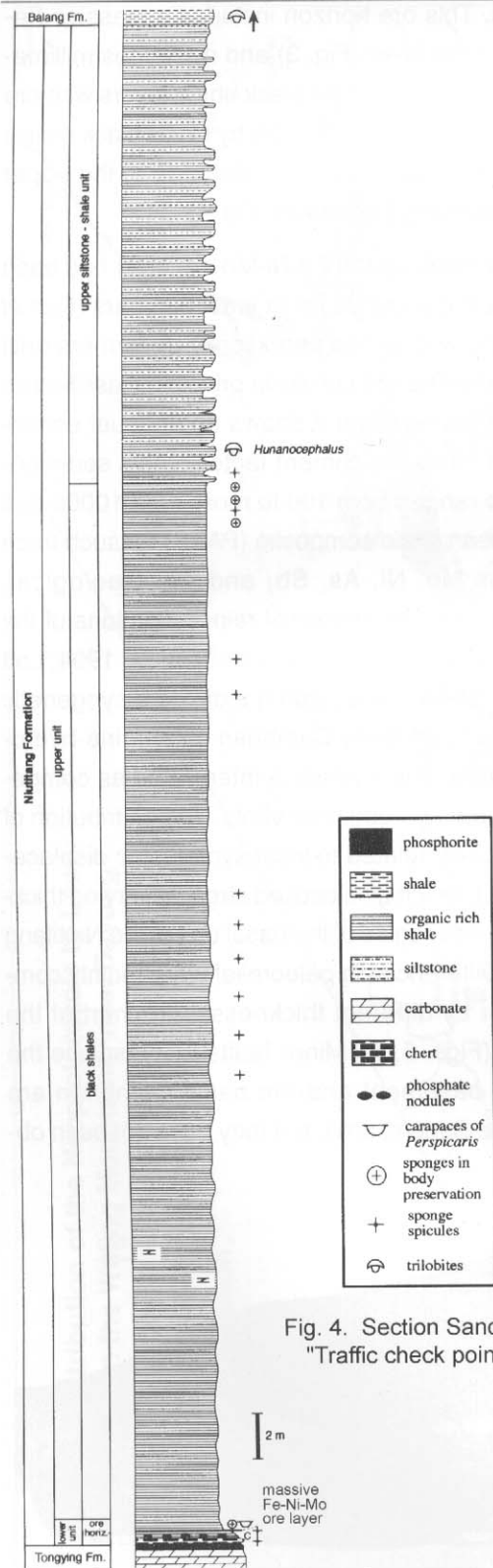


Fig. 4. Section Sancha-  
"Traffic check point".

served to crosscut the Cambrian black shales higher than 3.8 m above the ore debris layer. Brittle stockwork-like rocks with quartz and calcite veinlets occur below the ore horizon. Homogenization temperatures of fluid inclusions from the veinlets within or below the ore indicate a formation temperature of 99 to 263°C (Lott *et al.*, 1999).

The Fe-Ni-Mo ore debris horizon occurs at several localities over a distance of more than 60 km in the Wuling Mountains, south of Zhangjiajie (Fig. 1). However, the individual ore bodies and lenses are never more than about 100 m in lateral extent. This type of ore has also been reported from Lower Cambrian black shales in Yunnan, Guizhou, Jiangxi, and Zhejiang provinces. The arrangement of these localities within a belt, extending more than 1600 km in length, has been interpreted as being attributed to a major NE-SW-striking syntectonic fault zone (Steiner *et al.*, 2001).

The ore horizon is remarkable not only because of the evidence for Early Cambrian submarine-hydrothermal exhalations, but also because it contains fossil accumulations of bivalved arthropods, rare sponges, and shelly organisms (Steiner *et al.*, 2001) at several localities. Fossil assemblages similar to those from the Sancha area of Hunan have been found within the ore horizon as far away as northern Guizhou, approximately 400 km from Zhangjiajie. It can be assumed that the organisms present in the ore horizon were metabolically linked to chemoautotrophic bacteria occurring at specific vent sites.

A chronostratigraphic assignment of the Niutitang Formation is difficult to achieve in the Sancha area, because of the lack of radiometric dates and the lack of biostratigraphically

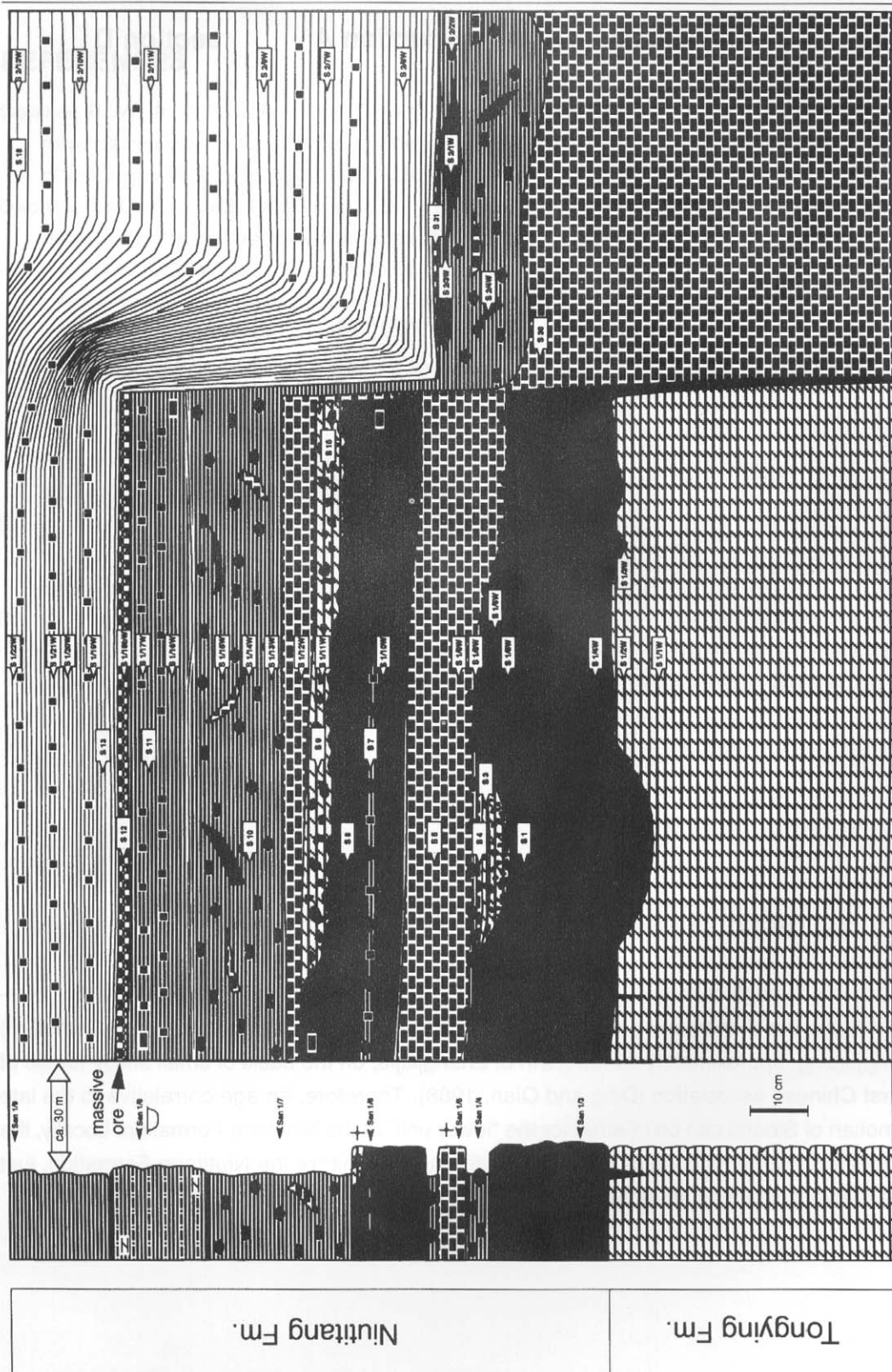


Fig. 5. Detail of the Lower Niutitang Formation with Fe-Ni-Mo ore layer and syntectonic structures at locality Sancha Traffic checkpoint.

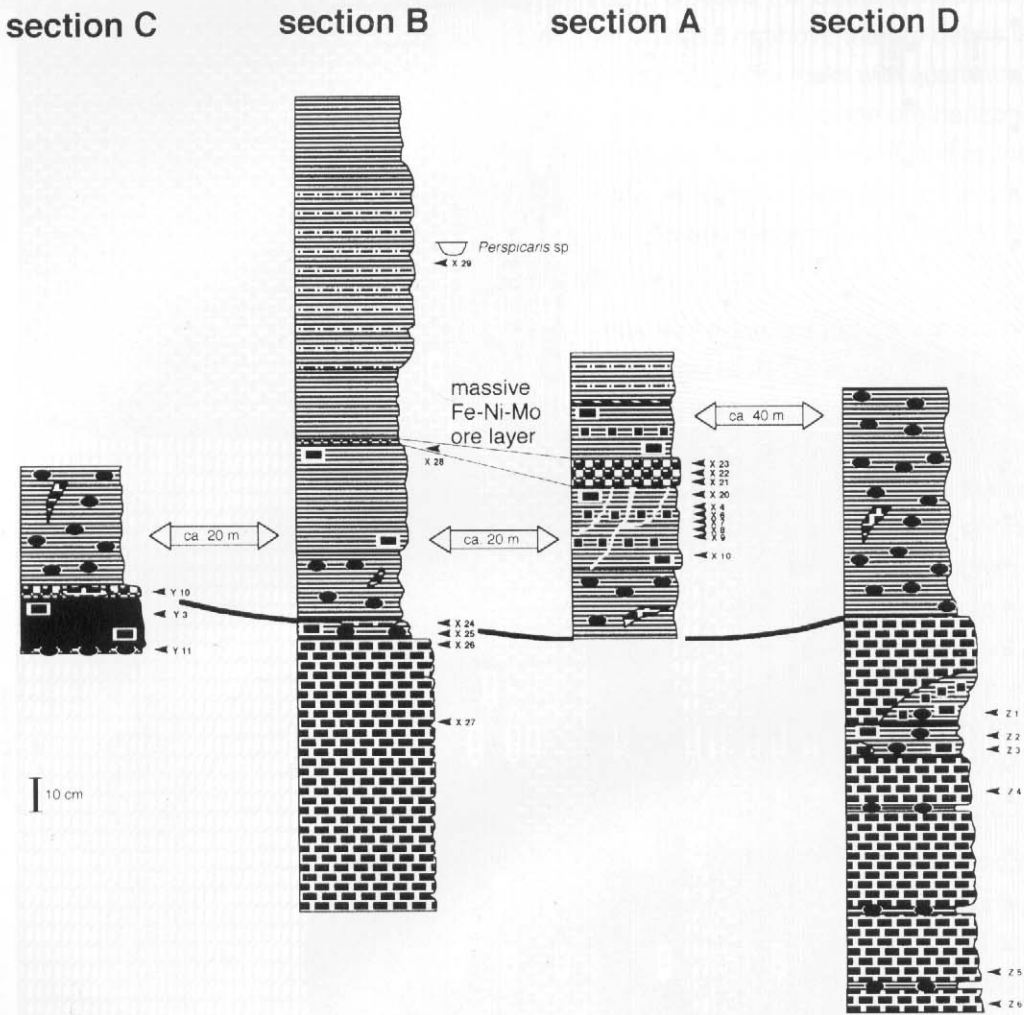


Fig.6. Sections measured at "Three Caves" near Sancha, Dayong, Hunan Province.

useful fossils through certain intervals. The "lower unit" of the Niutitang Formation can be correlated with the basal chert and phosphorite unit of the Yangjiaping Formation (Lower Cambrian) at Yangjiaping, approximately 90 km north of Zhangjiajie, on the basis of small shelly fossils of the first Chinese association (Ding and Qian, 1988). Therefore, an age correlative to the late Tommotian of Siberia can be inferred for the "lower unit" of the Niutitang Formation. Locally, the first trilobites (*Hunanocephalus sp.*) occur in the "upper unit" of the Niutitang Formation, just above a level containing abundant, articulated sponges (Steiner *et al.*, 1993).

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