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Mesozoic structural architecture of the Lang Shan, North-Central China: Intraplate contraction, extension, and synorogenic sedimentation

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Abstract

The Lang Shan, North-Central China, has experienced a complex Mesozoic to recent history of intraplate deformation and sedimentation. Well-exposed cross-cutting relationships document Jurassic right-lateral strike-slip faulting (transtension) followed by several tens of kilometers of Late Jurassic to Early Cretaceous north-northwest–south-southeast crustal shortening and development of an associated foreland basin. Since the Early Cretaceous, the south-central Lang Shan has undergone two phases of extension. The first, which occurred along north–south oriented structures, may represent collapse of an overthickened crust. The youngest deformation is represented by the active Cenozoic mountain-front normal fault system. This compound history may be the result of the complicated far-field effects of plate interactions combined with structural inheritance in a region adjacent to a rigid and undeformed crustal block, the Ordos block.

Keywords: Intraplate; China; Fold-thrust belt; Foreland basin; Continental extension; Ordos; Inner Mongolia; Yinshan

1. Introduction

The diffuse nature of plate boundaries has been documented over the nearly four decades since plate tectonic theory was proposed (see review by Gordon, 1998). The nature of how these diffuse, or intraplate zones, accommodate plate convergence is critical to understand the processes by which continents grow and subsequently deform. Intraplate belts of deformation provide key insights into the far-field effects of plate boundary interactions—those plate boundaries may now only be preserved as complex suture zones. In addition, intraplate belts and the associated sedimentary basins record a long and complex history of deformation (e.g. Teyssier, 1985; Kluth, 1986; Shaw et al., 1991; Hendrix et al., 1992; Ziegler et al., 1995, 1998; Sandiford and Hand, 1998; Darby et al., 2001; Davis et al., 2001; Ritts et al., 2001, 2004; Darby and Ritts, 2002; Johnson, 2004; Cope et al., 2005). Understanding these histories may afford the opportunity to better understand problems ranging from the reactivation of mechanical heterogeneities to development of large, non-marine sedimentary basins (Ziegler et al., 1998; Sandiford and Hand, 1998; Hand and Sandiford, 1999; Ritts et al., 2001, 2004; Darby and Ritts, 2002; Cope et al., 2005).

Asian, more specifically, Chinese examples of intraplate deformation have long been discussed in the geologic literature (e.g. Wong, 1929) and have recently begun to receive more attention (e.g. Hendrix and Davis, 2001). These intraplate belts of deformation may play a critical role in understanding the tectonic evolution of China and Asia including use as both passive strain markers and controlling features of younger, Himalayan–Tibetan structures especially given recent documentation of large-scale Cenozoic left-lateral strike-slip faulting beyond the margins of the Northern Tibetan

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Plateau (Darby et al., 2005; Webb and Johnson, 2006). Despite their importance for understanding continent evolution, the spatial and temporal distribution of pre-Cenozoic intraplate mountain belts in northern China remains unresolved.

The Lang Shan (Fig. 1), in the northwest corner of the Ordos Plateau (Fig. 1), contains a spectacular example of late Mesozoic intraplate crustal shortening and subsequent collapse with associated synorogenic sedimentation. We present new data that illustrate the structural architecture, document cross-cutting relationships, constrain the timing of deformation, and a thrust belt restoration from this poorly studied area. This study area is significant in that it provides additional constraints on the spatial extent and magnitude of Mesozoic intraplate deformation in China. Because the long-term structural evolution of this belt was accompanied at each stage by syntectonic sedimentation, the Lang Shan also provides an excellent record to the changing surficial environments that accompanied growth and decay of this intracontinental mountain belt.

2. Rock units and stratigraphy

2.1. Precambrian

Precambrian rock units in the Lang Shan were not differentiated by the authors. They consist mainly of foliated metasedimentary units such as quartzite, schist, and marble. Other basement lithologies include gneiss and some granitic plutons, some of which are foliated. Precambrian crystalline rocks, along with younger plutons, make up the majority of the rugged Lang Shan.

2.2. Late Paleozoic–Triassic granitoid plutons

A regionally extensive Late Paleozoic–Triassic (NMBGMR, 1999) batholith is well exposed in the central portion of the range (Fig. 2). The NMBGMR (1999) dated several of these plutons (U-Pb, zircon) and report ages from 292.3 to 205.1 Ma. Plutons in the batholith are mainly granites (quartz, grey to pink K-feldspar, plagioclase, and biotite) that lack a solid-state foliation. Outside the main batholith, several plutons intrude the Precambrian basement.

2.3. Jurassic Jr_u

The spatially largest exposure of Jurassic strata (Jr_u) in the south-central Lang Shan is a highly faulted, triangular-shaped exposure in the central portion of the study area (Fig. 2). These strata rest unconformably on crystalline basement along the southwestern margin of the exposure. The lower two-thirds of this exposure, which is at least 1 km thick, consist of boulder conglomerate (maximum clast size ~ 4 m) and sandstone. Conglomerate clasts include gneiss, granitoids, carbonate, and red sandstone. White carbonate sedimentary breccias are interbedded with brown sandstone and conglomerate along the southern exposure of this unit (N41°04.20′, E106°59′). These carbonate breccias only extend northward into the sedimentary section for a few tens of meters and have wedge-shaped geometries in cross-section that thicken and coarsen to the southeast. The source of the carbonate breccias is most likely the white marble found in the footwall of the normal fault that is locally preserved along the southeastern edge of the Jurassic section. The upper third of the section is a fine-grained sequence of buff to green sandstone, siltstone, and shale with minor

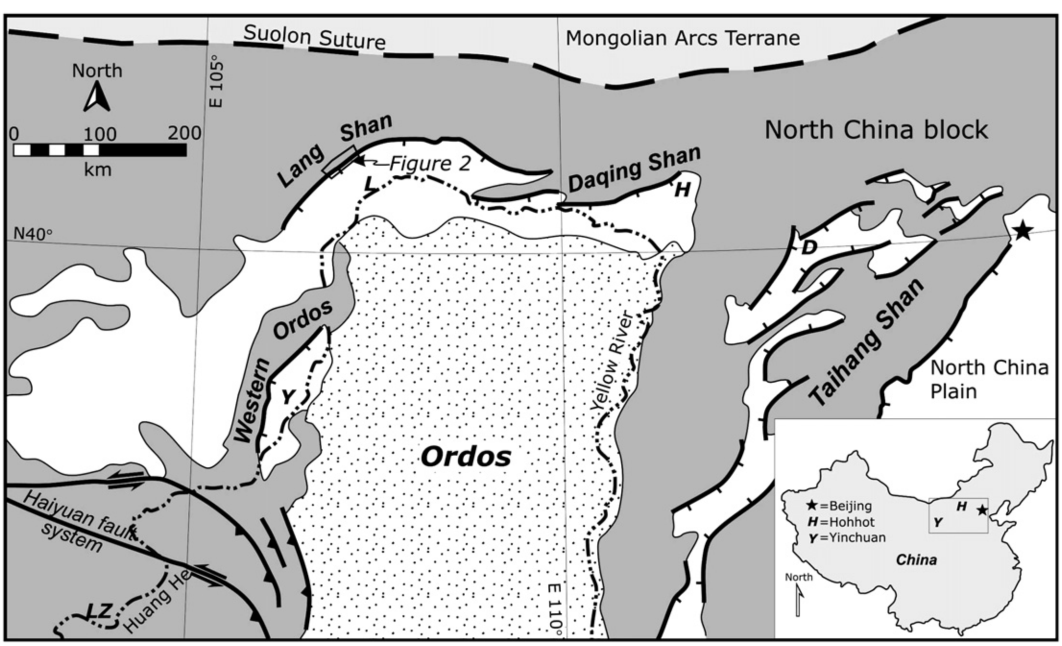

Fig. 1. Location map of the northern Ordos region, North China adopted from Darby and Ritts (2002). Light grey, Mongolian arcs terrane; medium grey, the Archean/Proterozoic-floored North China block; stippled pattern, the Ordos Plateau, formerly a Mesozoic basin; star, Beijing, D, Datong; H, Hohhot; L, Linhe; LZ, Lanzhou; Y, Yinchuan. Active structures adopted from Zhang et al. (1998). Note location of Fig. 2.