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Subduction-Accretion History of the Central Asian Orogenic Belt: Constraints from Mongolia

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The Central Asian Orogenic Belt (CAOB), one of the world's largest accretionary orogens, formed largely by subduction and accretion of juvenile material from the Neoproterozoic through the Paleozoic; Mongolia occupies a key central position. It is fringed by the Siberian craton in the north and by the Tarim and Syno-Korean cratons in the south. Several different summaries, syntheses and models have been proposed to explain the development of the CAOB. Mossakovsky et al. (1994) suggested the closure of small ocean basins by multiple subduction, the obduction of ophiolites and the accretion and collision of island arcs and microcontinents. In contrast, Sengör (1993) envisaged continuous, oceanward migration of a single subduction zone to create the entire Altaid collage.

We have sub divided the geology of Mongolia into 44 terranes: island arcs, continental margins, ophiolites, accretionary wedges, passive continental margins, microcontinents, turbidite overlap basins and continental margin arcs. Strike slip faulting has dismembered many terranes such as island arcs and ophiolites. The sub division allows us to make much-needed, detailed studies of individual terranes and their boundaries in order to confirm or modify their character and make-up. Some terranes previously synthesised from early-published records have been incorrectly defined.

There are seven cratonal terranes (microcontinents), the oldest of which is the Baydrag block in central Mongolia that has a zircon age on high-grade biotite tonalitic gneiss of 2650± 30 Ma (Mitrofanov, 1985). Most other cratonal terranes lack reliable isotopic data. We assume these terranes docked against an assemblage of already accreted arcs.

Of two major ophiolite terranes, Bayankhongor has a strike length of over 300 km and a Sm-Nd whole rock age of 569± 21Ma (Kepezhinskas et al., 1991). A complete ophiolite stratigraphy has been imbricated and thrust to the northeast over deep-water sediments probably on a continental margin (Buchan et al., in press). Within the thrust pile is a thrust slice of dismembered, undated island arc that is only a few hundred meters thick. The pile also contains a thrust slice of unmetamorphosed fossiliferous Carboniferous sediments. New geochronological data from granites that include the Bayankhongor ophiolite suggest that the ophiolite was obducted by thrusting in a collisional event, which lasted from 540 Ma to around 450 Ma (Buchan et al., unpub.). The post-Carboniferous thrusting was probably a long distance effect of Late Paleozoic collision in southern Mongolia. These relations demonstrate the complexity of thrust tectonics in this terrane collage.

Some other small ophiolites, located in island arc terranes, have a similar isotopic age from south to north; Khantayshir (568± 4 Ma, U-Pb zircon), Dariv (573± 6 Ma, U-Pb zircon), and Agardagh in Siberia just north of Mongolia (569± 1.1 Ma, U-Pb zircon, Pfander, 1999). In addition to these similar ophiolite ages, recent data from southern Tova associated with Agardagh ophiolite suggest that collision of arcs and continental fragments took place in this area at the same time as those in Bayankhongor and provide strong evidence that these ophiolites and those between them, were linked in a simultaneous subduction-accretion system. Some ophiolites with off-shore arcs were thrust northwards over their continental margins, but others southwards, from which we infer different senses of subduction polarity. These relations point to a geometrically complex tectonic assembly with variably oriented subduction zones.

Two passive margin terranes contain predominant quartzitic and limestone sediments typically of modern shelves on continental margins.

There are eight accretionary wedge terranes which consist of low-grade schists that contain many inclusions of mafic and ultramafic rocks. On the southern side of the Bayankhongor ophiolite is a 20 km wide accretionary wedge with common chlorite-muscovite-graphite schists intruded by andesite dykes; arc magmatism in a trench.

Age data, largely palaeontological, of the 11 island arc terranes suggest that those between Bayankhongor and the Chinese border range in age from Neoproterozoic in the north to Paleozoic in the south. An island arc in southern Mongolia has $^{40}Ar/^{39}Ar$ ages of 364± 3.5 Ma on porphyry copper ore and 313.0± 2.9 Ma on a cross-cutting porphyry dyke (Lamb and Cox, 1998). Eight back arc or fore arc terranes contain abundant turbidites with much volcanic debris.

Seven metamorphic terranes have unknown plate tectonic affinity or provenance. Some are high-grade, while others are predominantly low-grade. It would be incorrect to conclude that any of the high-grade terranes are very old, just because of their metamorphic grade.

In addition, we define two Permian Early Mesozoic continental margin arcs (Andean-type), which border both sides of the Mongole-Okhotsk suture in north-eastern Mongolia. They formed as a result of the two-way subduction of the Mongol-

Okhotsk Ocean. The northern arc contains porphyry copper deposits at Erdenet and Bayan Uul, which have $^{40}Ar/^{39}Ar$ ages of 207.4± 2.5 Ma (Early Jurassic) and 220-223 Ma (Late Triassic) respectively (Lamb and Cox, 1998). Only minor windows of Paleozoic rocks are exposed between the predominant plutons and lavas of these arcs.

Our results place limits on earlier tectonic models. The processes of subduction-accretion in Central Asia were more complex than previously realised. At present the paucity of reliable structural-isotopic-geochemical data prevent the creation of a single viable tectonic model to explain the subduction-accretion history and processes with time.

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Palaeozoic-Early Mesozoic Accretionary Tectonics of the Western Kunlun Range, NW China

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The western Kunlun Range of the northern Tibet Plateau has been regarded as a natural laboratory to reveal mountain belts. Many models have been proposed to interpret its geology and mechanism of formation but its origin is still debated. For example, Matte et al. (1996) and Mattern et al. (1996) proposed an early Paleozoic southward subduction superimposed by a Triassic northward subduction. Sengör and Okurogullari (1991) suggested a forearc accretionary model, the Turkic-type orogeny, suggesting a giant early Paleozoic northward subduction. Yao and Hsü (1994) also favored early Paleozoic northward subduction but emphasized backarc collapse archipelago orogeny. However, no backarc basins and forearc basins have been recognized positively in these models. The core of the question lies firstly on the Kudi ophiolite which occur in the core of this orogen. The Kudi ophiolite is thought to mainly constitute the Buziwan ophiolite in association with the Yixieke basaltic and andesitic pillowed and massive extrusives topped by ophiolitic turbidites, and was speculated to be an early Paleozoic mature oceanic basin (Deng, 1995), early Paleozoic (Pan, 1996) or late Paleozoic (even Triassic) backarc basin (Yao and Hsü, 1994; Hsü et al., 1995; Hsu and Chen, 1999; Yin and Harrison, 2000). However, no positive evidence has been provided. The nature and emplacement age of this ophiolite remains poorly understood. The second part of this question goes to the Kudi gneiss-schist complex south of the Kudi ophiolite. Was it a Precambrian continental fragment (XBGMR, 1993) or Caledonian mylonite (Matte et al., 1996)? Although Sengör and Okurogullari (1991) suggested it was Paleozoic subduction complex generated by subduction of oceanic ridge, it is challenged by recent zircon age 2040 Ma (Hu et al., 2001). Furthermore no evidence has been presented to improve the mélange nature of this gneiss-schist complex in their accretionary model (Sengör and Okurogullari, 1991).

Recent structural and tectonic approaches provide constraints for the ophiolite and tectonics of this orogen. The Kudi gneiss-schist complex is composed of various rock types including ultrabasic slices, marbles, various gneisses, schists, phyllites, quartzite and migmatites, sheared into a giant shear zone (Zhou, 1998; Zhou et al., 1999). Together with the Ar-Ar dating of 450–426 Ma for the shearing (Zhou, 1998; Zhou et al., 1999), indicating the majority of this complex was an accretionary prism, a scenario consistent with that of Sengör and Okurogullari