Vendian-Paleozoic Evidences of Crustal Break-up and Accretion in the Urals-Mongolian Fold Belt: A Tale of Three Supercontinents

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Urals-Mongolian fold belt is of critical importance for establishment and understanding of great tectonic cycles in the crustal history of Eurasia. Taking a central position in Northern Pangea, the belt unites and welds up many different fragments of earlier supercontinents –Rodinia and Panterra (Pannotia).

Recently Puchkov (2001) has given additional evidence to

the fact that a supercontinent bigger than Gondwana had been formed in the Late Vendian (600-550 Ma) as a result of the Panafrican-Brasiliano-Cadomian-Preuralian collision and orogeny. In addition to Gondwana, the supercontinent enclosed Baltica and Siberia. Simultaneously with the Late Vendian collision (starting somewhat earlier), rifting and separation of Laurentia from Amasonia and Baltica took place as the last events of the Rodinia break-up. The lines of the evidences for this interpretation are as follows: 1. Preuralide orogen is contemporaneous to Cadomian one and may constitute a fragment of the latter, therefore tying up Baltica and Gondwana; 2.The Paleozoic passive margins of the continents under discussion were formed in two stages: a) Vendian/Early Cambrian (Greenland-Appalachian-Ouachita, Scandinavian - Teysseyre-Tornquist) and b) Late Cambrian/Early Ordovician (Uralian, North Gondwanan, East Siberian) (modern geographic orientation here and elsewhere); 3. The paleomagnetic data, taking into account longitudinal uncertainties, do not contradict but rather support the idea (Tornquist et al., 1996; Popov et al., 2000).

The Neoproterozoic fallout of Rodinia resulted in a complete reorganization of oceans. Pacific, Paleoasian and Iapetus oceans were formed at least by the beginning of Cambrian. The relics of at least three Cambrian island arcs are known in the Uralo-Mongolian belt: Salairian arc around the western and southern periphery of the Siberian continent, Boschekul-Chingiz arc (in the Central Kazakhstan) and Tien-Shan arc to the south of the Northern Tyan-Shan terrane. All of them could be fragments of a continuous chain of arcs forming a single subduction zone in the Paleoasian/Paleopacific ocean. By the end of Cambrian, the subduction system was strongly rebuilt. The Salairian island arc collided in the Late Cambrian-Early Ordovician with microcontinents of the Siberian group and accreted to the Siberian continent (Salairian orogeny). The Chingiz and Tyan-Shan arcs collided first in Cambrian and then in the Ordovician with several microcontinents such as Kokchetav, Ulu-Tau, Northern Tyan-Shan, Aktau and others (probably they were fragments of Rodinia not reassembled by the Late Vendian collision). Finally, these collisions gave birth to Kazakhstanian continent, which accreted initially like a snowball (Mikolaychuk et al., 1997; Kheraskova, 1998; Degtyarev, 1999; Hermann et al., 1999). Simultaneously, the Taconian arc collided with Laurentia, causing the accretion of continental margin of the latter and inversion of the subduction zone (Puchkov, 1988).

The Early Ordovician separation of Siberia and Baltica from Gondwana gave birth to Paleouralian and Paleotethys (Rheic and Galician-Massif Central, after Matte, 1991) oceans with a series of microcontinents such as Western and Eastern Avalonia, Armorican archipelago, Ust-Urt, East Uralian, Kara and others. Much later in the Paleozoic, the relics of the Paleouralian and Paleoasian oceans with their terranes approached and came to a close position in the Uralo-Mongolian fold belt due to the well-known ~180° anti-clockwise rotation of the Siberian continent and enclosing lithospheric plate during the Paleozoic time.

In the Ordovician, the Paleotethys and Paleouralian oceans were the areas of predominant spreading, though the evidence for Ordovician subduction had been given for the Paleozoic complexes of the Alps (von Raumer and Neubauer, 1993); the existence of so-called Guberlya arc in the Paleouralian ocean seems to be not supported by modern stratigraphic data. Only in the Denisovka zone of the easternmost Urals, tholeiitic basalts and jaspers change upwards by volcanomyctic cherty flysch, which could be an indication of the arc formation. But Denisovka zone itself reminds very much of some epioceanic zones of kazakhstanides and could exist primarily at a great distance from the Uralian margin of Baltica. Paleomagnetic data (Svyazhina et al., 1998) for Denisovka latitude, is close to the Kokchetav terrane of Kazakhstan and strongly different from Baltica.

The partial jamming of the subduction zone as a result of the above mentioned collisions, has lead to a new geodynamic reorganization of the lithosphere. In the Silurian, an oroclinal bend of the subduction system was formed around the northern and eastern margins of Baltica, with an inverted, outward dip of the subduction zone. As a result, Laurentia collided with Baltica, Iapetus ocean closed, Caledonides and a new continent of Laurussia formed (Torswik et al., 1996). At the prolongation of this subduction zone Tagil arc existed, with its relics in the Tagil and East Uralian zones and probably with prolongation in the Boschekul-Chingiz zone of Kazakhstan (Degtyarev, 1999).

This collision caused in turn a new restructuring of the subduction system. Since the Emsian time, it is tentatively traced to the south and east of Laurussia, being inclined under Gondwana. It is supposed here that the development of this system has lead to an arc-continent collision with Laurussia causung the Acadian orogeny. At the extension of the same subduction zone in the Paleouralian ocean an Irendyk island arc existed, which later was transformed into Magnitogorsk arc. The Tagil arc was partially incorporated into the Magnitogorsk one as a terrane. This part of the subduction zone was inclined under Siberia. Another subduction zone dipping under Siberia has been formed in this time in Altay (Yolkin et al., 1994). Devonian subduction is also revealed around the Kazakhstanian continent at its margins, dipping under it and causing a formation of the famous volcano-plutonic belt (Kurchavov et al., 1998). It is possible that we have here again the fragments of a single subduction zone, making a strong oroclinal bend around the Kazakhstanian continent. The reconstruction is in only a slight contradiction with paleomagnetic data of Burtman (1999) for the relative position of the Kazakhstanian and Uralian structures in the Devonian time.

Acadian collision caused an inversion of the subduction zone situated to the south of Laurusia; at the back of this zone, in Europe, tensional structures started to develop in the Late Devonian (Puchkov, 1988). In the same time, the Magnitogorsk island arc collided with the South Uralian part of the Laurussia passive margin, so the margin accreted, early variscan folding and thrusting took place and the subduction zone also experienced an inversion. The Valeryanovsky volcano-plutonic belt was formed; it existed for a long time (since Tournaisian till the Early Bashkirian in the Carboniferous time), which implies that a considerable stretch of oceanic crust (not less than 400–500 km wide) was subducted. It was the last portion of the oceanic crust available; at the moment when it disappeared, a collision between Baltica and Kazakhstanian continents started.

In the Middle Urals, the last short-lived impulse of subduction gave birth to a chain of the Verkhisetsk group of granite-tonalite massifs (Bashkirian in age); after that, a collision between Baltica and the Magnitogorsk arc started here, migrating to the north, along the strike of the continental margin, demonstrating its oblique character.

The collision went on during Moscowian, Late Carboniferous and Permian time, resulting in formation of a bi-lateral orogen of Uralides. By that time the Uralian orogen was continuously connected with the other orogens of the Uralo-Mongolian foldbelt. It developed penecontemporaneously with them, being a result of nearly simultaneous collisions of several continents, constituting a new supercontinent Pangea.

In the Early Jurassic time, as a consequence of large-scale transcurrent movements between continental masses within Pangea, the last oceanic gap that probably existed in the North of the Western Siberia was closed and blocks of Baltica and Siberia came into immediate contact and collided, giving birth to Pay-Khoy- Novaya Zemlya- Taymyr foldbelt.

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