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The Anabar Collision System As an Element of the Columbia Supercontinent: 600 Ma of Compression (2.0–1.3 Ga)

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The ancient cratons exposed at the surface (shields) and overlapped by sedimentary cover (platforms) are a mosaic of the accreted paleocontinents (microcontinents [12]) transformed into tectonic blocks (terranes and composite terranes, superterranes-provinces) limited by collision zones (sutures or collision sutures). The Early Precambrian collision systems were formed as mountainous edifices of the Himalayan or Alpine types [7]. At certain stages of the Precambrian geological history, the collision events embraced the entire globe and all sialic masses presumably gathered into one common aggregate that represented a supercontinent at that time [1, 9, 10]. Thereby, collision, hummocking, and compression of terranes likely functioned continuously over the entire life of the supercontinent and its surface was overlain by platformal sedimentary cover. The extremely long compression of the crust was established in the Anabar collision system.

According to numerous but fragmentary determinations, the age of the materials that made up terranes of the Siberian Craton covers 3.4–2.3 Ga (see the review in [4, 6]). As follows from the Sm–Nd mineral isochrons (garnet, pyroxenes, plagioclase, and whole-rock samples from plagiogneisses and other metamorphic rocks), granulite metamorphism is dated at 1.8–1.9 Ga. The same estimates were obtained with the U–Pb method for zircons from migmatites, granitoids, and charnockites localized in collision sutures. The coincidence of dates for granites and granulites indicates a common heating of the collision prism in terms of the model developed in [11].

The Anabar collision system consists of granulite–gneiss and granite–greenstone terranes that make up the Anabar and Olenek provinces. In addition to the previously known age determinations for the Anabar Shield [6], the samples of crustal xenoliths entrained by kimberlite pipes and the borehole cores from a depth of 2–4 km (Fig. 1) were recently dated. The samples are composed largely of granulite-facies metamorphic rocks, and 105 isotopic dates have been obtained [4, 5]. The Sm–Nd method yielded a model $T_{\rm Nd}$DM value of 3.2 to 2.4 Ga for the protolith and mineral isochron ages of 2.20–1.63 Ga for metamorphism [4]. These estimates are partly supported by U–Pb zircon dating [5]. A few $T_{\rm Nd}$DM(2st) values equal to ~2 Ga indicate the younger emplacement of mafic rocks that are coeval with the well-known dolerite dike in anorthosites [6] and likely related to the local collapse of the system (Fig. 2). The Rb–Sr isochron ages shift to younger values up to 1.3 Ga [4] due to the lower temperature (~300°C) of the closure of the Rb–Sr isotopic system. For the samples dated with both methods, the Rb–Sr age value is approximately 20% less than the Sm–Nd value. This fact indicates a lag of approximately 300 Ma for the Rb–Sr system closure and the age of collision prism cooling that lasted until 1.3 Ga ago.

The Kenorland supercontinent, which existed about 2.7 Ga ago, was probably the first supercontinent in geological history. The second supercontinent was represented by Laurentia (presumably 2.0–1.8 Ga ago [12]). These supercontinents were subsequently termed Pangea-0 and Pangea-1 [10], or Monogea and Megagea [9]. The

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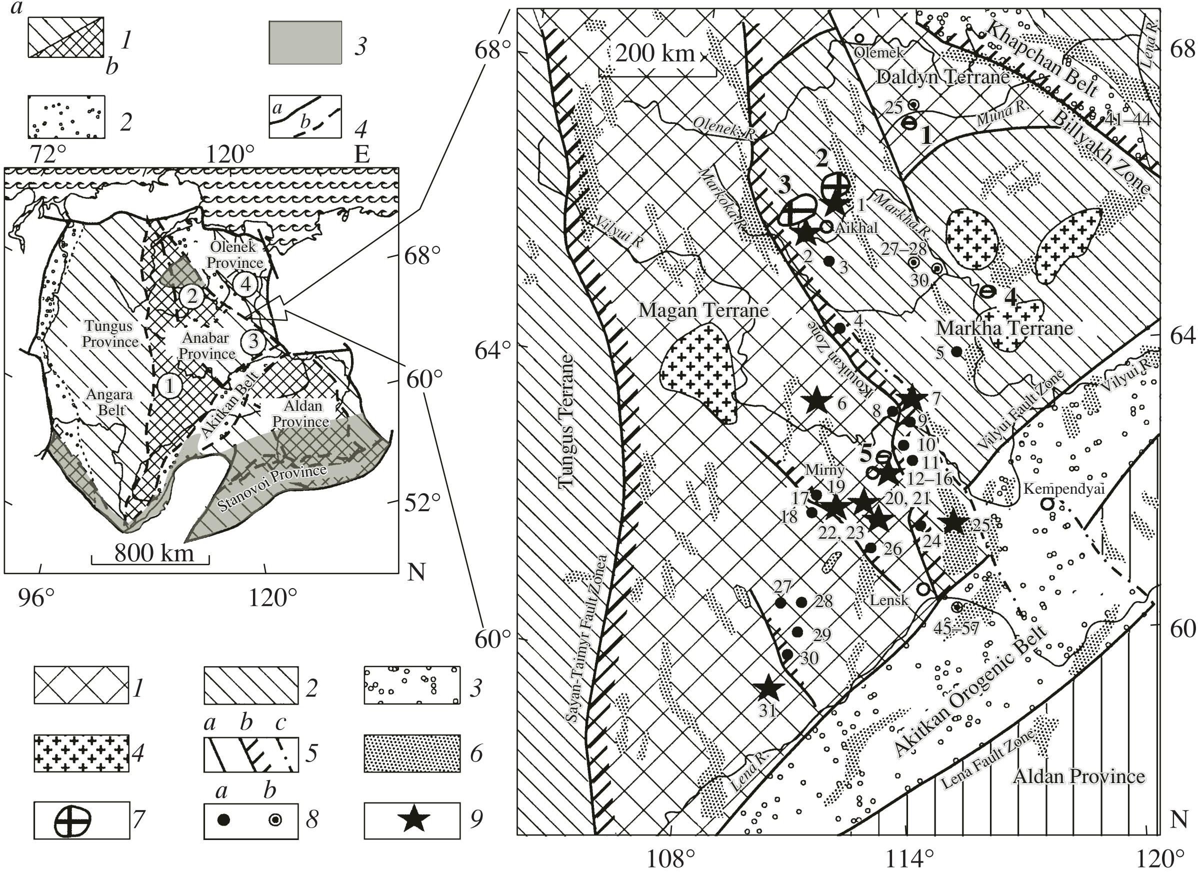

Fig. 1. Geological sketch map of the basement and location of sampled boreholes and kimberlite fields in the study region [4, 6]. (*1*) Granulite–gneiss terranes; (*2*) granite–greenstone terranes; (*3*) metavolcanics, metasedimentary rocks, and granitoids of foldbelts; (*4*) granitic batholiths [2]; (*5*) faults: (*a*) Paleoproterozoic sutures, (*b*) NE-dipping thrust faults, (*c*) Phanerozoic strike-slip faults; (*6*) positive magnetic anomalies ($\Delta T_a > +5$ mOe [3]) that delineate the basement structure; (*7*) kimberlite fields with sampled crustal xenoliths: (**1**) Muna, (**2**) Daldyn, (**3**) Alakit, (**4**) Nakyn, (**5**) Mirny; (*8*) boreholes and samples: (*a*) boreholes and their numbers [6], (*b*) sample numbers [8]; (*9*) boreholes used for isotopic dating of rocks [4, 5]. The inset on the left demonstrates the structure of the Siberian Craton [6]: (*1*) Archean terranes (3.5–2.5 Ga): (*a*) granite–greenstone, (*b*) granulite–gneiss; (*2*) Proterozoic foldbelts (2.4–2.0 Ga); (*3*) exposed areas; (*4*) fault zones: (*a*) craton boundaries, (*b*) sutures within craton. Terranes (numerals in circles): (1) Magan, (2) Daldyn, (3) Markha, (4) Birekte.

entire geological evolution of continents turns out to be a cyclic process from "Pangea to Pangea" [1]. The Laurentia supercontinent comprised almost all collision orogens of that time. However, accretion was probably more prolonged. It turned out that the younger accretionary magmatic orogens of Baltica and the southern Canadian Shield directly prolonged the history of the Paleoproterozoic supercontinent [15]. Having begun 2.0 Ga ago, its evolution apparently continued until 1.3 Ga ago [15]. In such an understanding, this Paleoproterozoic supercontinent was named Columbia (Fig. 3), which is consistent with broad treatment of the terms Laurasia and/or Pangea-1.

The Anabar collision system, probably situated at the margin of this supercontinent, was affected by centripetal compression 2.2–1.6 Ga ago. This stress orientation was suggested previously on the basis of theoretical preconditions [14]. The confining compression provided compactness of the supercontinent and the high standing of the continental crust therein. The established duration of collisional compression (600 Ma) is the maximal one among the estimates known to date for collision systems. In particular, one of the longest cycles of compression–collapse–repeated compression reported in the literature occurred 1.92–1.81 Ga ago in southern Finland and lasted for about 100 Ma [13]. The duration of compression elucidated for the Anabar Shield is comparable with the lifetime of Phanerozoic platforms. The Columbia supercontinent probably was a rather stable continental edifice that was supported on its sides by inward plunging subduction zones. The data obtained indicate that the crust of ancient supercontinents was stable over a long time. In particular, the Columbia supercontinent is comparable in stability with Phanerozoic platforms.

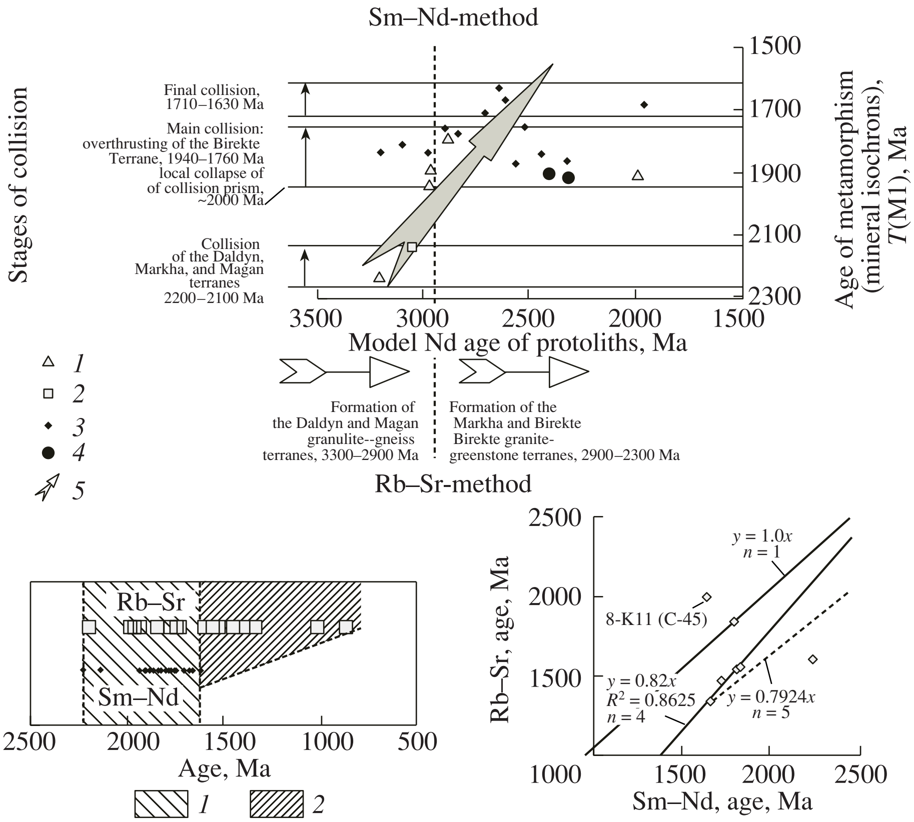

Fig. 2. The age of formation and metamorphism of the Anabar collision prism (after [4]). (*1–4*) Sampled terranes: (*1*) Daldyn, (*2*) Magan, (*3*) Markha, (*4*) Birekte; (*5*) Temporal trend of collision metamorphism. Types of zones (for the Rb–Sr data): (*1*) zone of coincidence with ages determined by other methods; (*2*) zone of younger values.

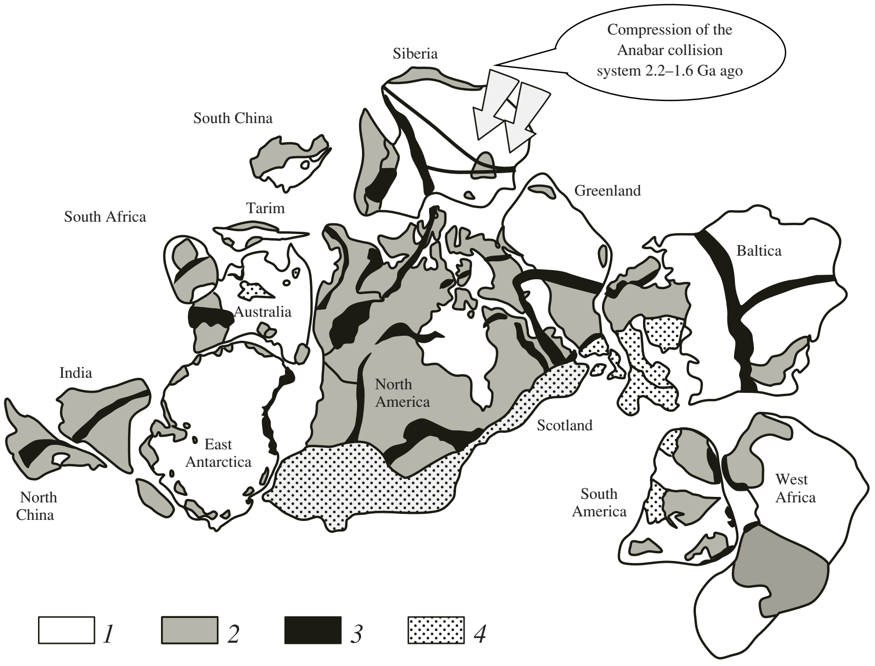

Fig. 3. Reconstruction of the Paleoproterozoic Columbia supercontinent [15] and position and orientation of compression in the Anabar collision system [5, 6]. (*1, 2*) Archean and Paleoproterozoic basement: (*1*) buried beneath Phanerozoic rocks or continental ice, (*2*) exposed; (*3*) collision orogens, 2.1–1.8 Ga; (*4*) accretionary orogens, 1.8–1.3 Ga.

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