



Formation of the Greater Caucasus by two-stage closure of a relict ocean basin and the transition from soft to hard Arabia-Eurasia collision

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The Caucasus region accommodates the majority of orogen-perpendicular shortening in the Arabia-Eurasia collision zone between the Black and Caspian seas, and developed from Cenozoic closure of a Mesozoic marine back-arc basin that extended from the Paleozoic crystalline basement of the Greater Caucasus (GC) in the north to the Mesozoic arc basement of the Lesser Caucasus (LC) in the south (e.g., 1). During the Paleocene/Eocene this basin, together with the still extant Black and South Caspian basins, formed part of the eastern Paratethys (e.g., 2). Reconstruction of the Pontide-Lesser Caucasus orocline indicates a minimum width for this basin of 200-280 km (3) although ~350-400 km has been proposed (4). This basin had spatially distinct detrital zircon provenance at the time of maximum extent, with a northern domain dominated by late Paleozoic grains and a southern domain characterized by Mesozoic and Cenozoic grains and a paucity of late Paleozoic grains (4). Initial closure of the Caucasus basin was underway by the Oligocene (5) during soft Arabia-Eurasia collision, and eventually shortened the sedimentary cover of the Caucasus basin by at least ~200 km, based on balanced crustal-scale cross sections (6). This is a minimum because it does not account for shortening in the LC (7) or non-accretionary underthrusting. Closure continued through the Miocene until the arc basement of the LC collided with the Paleozoic basement of the GC, leading to the onset of hard collision and an acceleration in rock and surface uplift of the GC at ~5 Ma (5). Recent acceleration of exhumation is required by rapid recent cooling rates combined with moderate regional exhumation depths in the Georgian GC: extrapolation of post-5 Ma cooling rates of ~25°C/Myr back to the onset of shortening predicts that deep crustal levels (~875°C) should be presently exposed in the core of the GC. However, low-grade slate and unmetamorphosed shale are the rock types presently exposed across most of the orogen. In Georgia, the Main Caucasus Thrust is a mylonitic shear zone that is < 100 m thick and locally carries Paleozoic basement in the upper plate (8). At deeper structural levels, a north-dipping zone of seismicity beneath the eastern GC implies subduction of an oceanic slab at least 130-280 km long, while a lack of seismicity west of 45°E is inferred to reflect recent slab breakoff (9). The orogenic structure of the GC is similar to the Himalayan thrust belt, although the magnitudes of shortening and exhumation in the GC appear lower. As such, the GC records an earlier stage of orogen development during continental collision.

(1) Zonenshain & Le Pichon 1986, *Tphys.* 123, 181; (2) Popov et al. 2004, Eds., *Lithological-paleogeographic maps of Paratethys*: Schweizerbart'sche Verlagsbuchhandlung, Stuttgart. (3) van der Boon et al. (2018) *EPSL* 482, 454; (4) Cowgill et al. 2016, *Tectonics* 35, 2918; (5) Avdeev & Niemi 2011, *Tectonics* 30; (6) Trexler et al. 2018, EGU abstract; (7) Young et al. 2018, EGU abstract; (8) Vasey et al. 2018, EGU abstract; (9) Mumladze et al. 2015, *GeoResJ* 5, 36.