What Made Denali so Tall? Structural Geology of the High Peaks of the Alaska Range

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Southern Alaska is deforming due to collision of the Yakutat terrane, and it has been on going for the last 25-30 Ma. Studies of young faults and folds, crustal earthquakes, and geodetic data indicate that part of southern Alaska, south of the Denali fault, is being extruded westward as the collision progresses. The Denali fault is the principle intracontinental fault in interior Alaska accommodating this collision, with right-slip at a rate of about 1 cm/yr. Vertical deformation is also linked to the collision, and fission track data show that exhumation of Mt. McKinley (Denali) began about 6 Ma

The two tallest peaks of the Alaska Range, Mt. McKinley and Mt. Foraker, rise 2-3 km above the surrounding peaks and lie adjacent to the Denali fault system. A 22 degree bend in the right-lateral Denali fault system is north of the summit of Mt. McKinley. This geometry caused contractional deformation on the inside, or south side, of the bend, resulting in uplift of Mt. Foraker and Mt. McKinley. Contractional deformation is focused on a thrust fault beneath the Foraker massif, and on a series of thrust faults between the McKinley pluton and the adjacent Ruth pluton. Both major thrust fault systems strike northeasterly, are southwest vergent, and have gouge zones more than 100 m thick. The summit of Mt. Foraker (17,400 feet) and the ~38 Ma Foraker pluton are in the hanging wall of the Foraker thrust. This thrust is responsible for the high elevation of Mt. Foraker, and it extends northeasterly and connects with the Denali fault. There is a series of thrust faults southeast of Mt. McKinley between the ~56 Ma McKinley and Ruth plutons, which I refer to as the Pittock Pass-Rooster Comb series of thrusts. The ~56 Ma McKinley granite is thrust over Jura-Cretaceous country rocks along the Rooster Comb thrust.

Mt. McKinley and Mt. Foraker have a different position with respect to the subjacent thrust faults. The summit of Mt. McKinley is 16 km northwest of the toe of the Rooster Comb thrust, whereas the summit of Mt. Foraker is 6 km northwest of the Foraker thrust. Only a small part of the southwestern intrusive contact of the McKinley pluton is exposed. The northeastern contact is well exposed and there is no evidence that it is significantly offset along any fault. Therefore, it appears there are no large faults within the McKinley pluton. Shallowly dipping fractures are common in the northern half of the McKinley pluton and may reflect deformation of the pluton over a thrust-fault ramp. There is a prominent series of northwest-striking conjugate fractures within the southern half of the McKinley pluton and the adjacent rocks to the south. These fractures are perpendicular to the northeast-striking thrust faults and taken together, constitute an orthorhombic fault set, which allows for non-coaxial brittle deformation of the region inside the bend of the Denali fault. The age of the master thrust faults is difficult to constrain, but they are likely young and possibly active as indicated by a number of lines of evidence. The Rooster Comb thrust correlates with an inflection point in the topography of the range. Also, a fission track study noted an offset of fission track ages along the trend of this thrust that is consistent with thrust motion. The fission track study, which showed that exhumation of Mt. McKinley began around 6 Ma and continues to the present, implies there must be young (post 6 Ma) deformation. The Susitna Glacier thrust fault ruptured in the 2002 Denali fault earthquake. It strikes northeasterly and intersects the Denali fault. The Foraker and Rooster Comb thrusts have the same geometry with respect to the Denali fault.