Tectonic implications of a late Paleozoic volcanic arc in the Talkeetna Mountains, south-central Alaska

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ABSTRACT

Reconnaissance studies in the Talkeetna Mountains of south-central Alaska disclosed an Early Permian volcanogenic sequence several thousand metres thick. These rocks are interpreted to represent a volcanic arc system that was accreted to the North American plate in late Mesozoic (probably Cretaceous) time. The northeasterly trend of the volcanic arc system and the parallel structural grain of the Talkeetna Mountains are part of the structural bend of southern Alaska commonly considered to be the result of oroclinal bending, which may instead reflect the shape of the late Mesozoic continental North American plate. The western part of the Denali fault system may be part of a wide, complex zone of high- and low-angle thrust faults rather than the prolongation of an arcuate strike-slip fault system.

INTRODUCTION

Reconnaissance geologic investigations in the Talkeetna Mountains, south-central Alaska, revealed a dominantly marine sequence of upper Paleozoic metavolcanic and metavolcaniclastic rocks, several thousand metres thick, interlayered with subordinate beds of marble and phyllite (Csejtey, 1974). These rocks range in age from Pennsylvanian(?) to Early Permian (late Leonardian) and are interpreted to represent the southwestern continuation of a volcanic arc system recognized previously in the eastern Alaska Range by Richter and Jones (1973), Bond (1973), and Richter and Dutro (1975). This paper describes the upper Paleozoic rocks of the Talkeetna Mountains and speculates on their regional tectonic significance.

GEOLOGIC SETTING

The roughly circular and geologically poorly known Talkeetna Mountains of south-central Alaska, located south of the central Alaska Range and north of the Chugach Mountains (Fig. 1), lie near a critical area where the Aleutian volcanic arc terminates on continental crust. In addition, the Talkeetna Mountains are bracketed by two major, currently active fault systems: the Denali fault on the north and the Castle Mountain fault on the south (Fig. 1).

The geologic backbone of the Talkeetna Mountains is a northeast-trending batholithic complex of Jurassic to early Tertiary tonalite and granodiorite. Bed rock north of this complex consists of upper Paleozoic metavolcanogenic rocks and Cretaceous metagraywacke and argillite. South of the batholithic complex, Jurassic and Cretaceous volcanic and sedimentary rocks dominate. The Talkeetna Mountains underwent several periods of complex deformation, resulting in a pronounced northeast-trending structural grain.

UPPER PALEOZOIC VOLCANIC ARC ROCKS

Lithology. The upper Paleozoic metavolcanogenic rocks of the Talkeetna Mountains crop out in a continuous belt, 30 km wide, that trends northeastward for 160 km. These strata constitute an interlayered heterogeneous, dominantly marine sequence. Over 5,000 m of section is exposed, but its base is not exposed. The sequence consists mostly of metamorphosed flows and tuff of basaltic to andesitic composition and of coarse- to fine-grained metavolcaniclastic rocks, with clasts composed chiefly of mafic volcanic rocks. Mudstone, thick-bedded to massive bioclastic marble, and dark gray to black phyllite are subordinate.

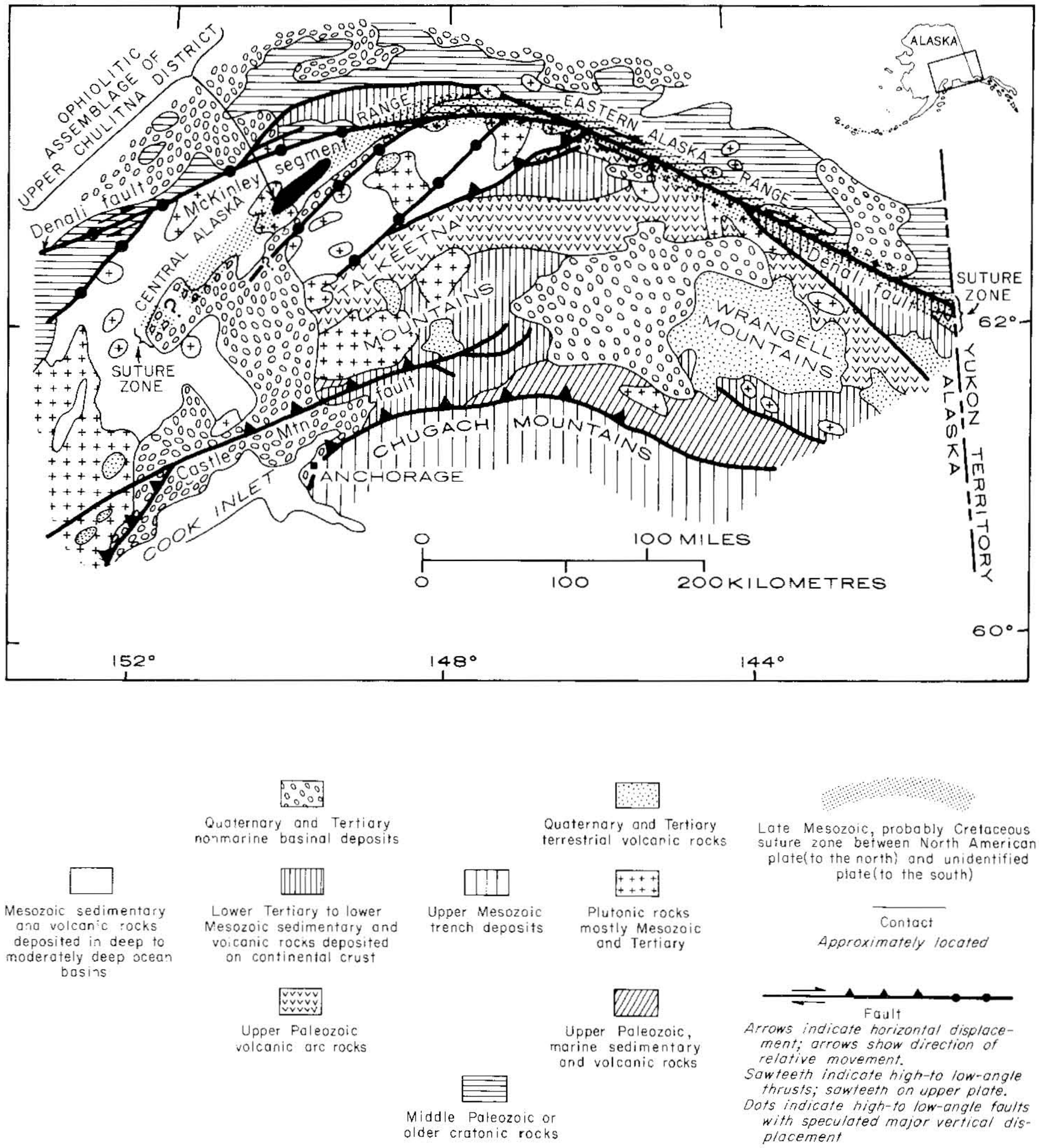

Figure 1. Geology of Talkeetna Mountains and surrounding area, showing major fault systems and proposed suture zone. Geology modified after King (1969), Clark and others (1972), Beikman (1974), Smith (1974), MacKevett and Plafker (1974), Reed and Lanphere (1974), and Detterman and Plafker (1975, oral commun.).

The various rock types of the sequence form conformable but lenticular units of limited areal extent. The metavolcaniclastic units, typically crudely layered and poorly sorted, reach thicknesses in excess of 1,000 m. The thickness of the phyllite units ranges from a few metres to several hundred metres, whereas the marble units are generally only a few tens of metres thick. The metavolcanic and metavolcaniclastic rocks constitute, in roughly equal proportions, approximately four-fifths of the sequence by volume. The whole sequence has been tightly folded and complexly faulted, and all its rocks have been regionally metamorphosed into mineral assemblages generally of the greenschist facies and locally of the amphibolite facies of Turner (1968). Petrographic descriptions of these rocks were given by Csejtey (1974).

Origin. The metavolcanogenic sequence is interpreted to have been deposited dominantly, if not exclusively, in a submarine environment of moderate to shallow depth. This is indicated by the presence of marine fossils in the interbedded marble and by echinoid spines in many of the metavolcaniclastic rocks. The thick and crude compositional layering in the clastic rocks suggests rapid deposition. The angular to subrounded shapes of the rock clasts, dominantly of mafic volcanic rocks, in the metavolcaniclastic strata suggest nearby source areas. The metaflows and metatuff appear to have been derived from nearby volcanic centers. The marble probably signifies deposition of calcareous bioclastic material by high-energy currents on shallow banks of limited areal extent.

The composition and character of the Talkeetna Mountains metavolcanogenic sequence, as well as regional geologic considerations, strongly suggest that these rocks are the remnants of a complex volcanic arc system.

Age and Correlation. One of the marble units intercalated with metavolcanic rocks near the top of the exposed metavolcanogenic sequence yielded a well-preserved fauna of crinoid columnals and brachiopods. (The fossil locality is in the Talkeetna Mountains C-4 quadrangle, lat 62°37′14″ N, long 148°48′35″ W.) The host rock and fauna were described and interpreted by J. T. Dutro, Jr. (1974, written commun.) as follows: "This recrystallized limestone is composed almost entirely of echinoderm debris, including large columnals up to 2.5 cm in diameter. Brachiopods were silicified and then recrystallized, but some are generically identifiable. These include: one specimen of *Arctitreta*, several pedicle valves of *Horridonia* and a dozen specimens of small- to medium-sized *Spiriferella*. This is definitely a Permian assemblage, although limited in kinds of brachiopods. Similar fossils have been identified from the upper limestone member in the Eagle Creek Formation of the Mankomen Group in its type area. These genera are also present in the Tahkandit Limestone of east-central Alaska." According to Dutro, these brachiopods suggest a late Early Permian age, since the upper limestone member of the Eagle Creek Formation was interpreted by Richter and Dutro (1975) to be upper Leonardian (Lower Permian) and the Tahkandit Limestone was considered by Brabb and Grant (1971) to range from upper Leonardian to lower Guadalupian (Lower Permian) in age.

Other marble units, occurring at lower stratigraphic levels in the metavolcanogenic sequence, contain similar but generically unidentifiable crinoid columnals, brachiopods, bryozoans, and sparse corals. The crinoid columnals are by far the most abundant, and all have circular outlines. These faunal assemblages, according to A. K. Armstrong (personal commun.) suggest late Paleozoic ages.

On the basis of all the available fossil evidence, most of the Talkeetna Mountains metavolcanogenic sequence is considered to be Early Permian in age. Regional correlations and the apparently great thickness of the metavolcanogenic sequence suggest that the lowermost parts may be as old as Pennsylvanian.

Rocks similar in age and lithologic composition to the Talkeetna Mountains metavolcanogenic sequence have been described from the eastern Alaska Range by Richter and Jones (1973), Bond (1973), and Richter and Dutro (1975). Lithologically similar but undated rocks were mapped by Smith (1974) along the south flank of the central Alaska Range.

Correlative rocks in the eastern Alaska Range belong to a several-thousand-metre-thick conformable sequence of Middle Pennsylvanian andesitic volcanic rocks, Middle Pennsylvanian to Early Permian volcaniclastic and calcareous volcaniclastic rocks, and Early Permian (Wolfcampian to Leonardian, possibly early Guadalupian) nonvolcanogenic marine argillite and limestone [the Tetelna Volcanics, the Slana Spur Formation, and the Eagle Creek Formation, respectively, of Richter and Dutro (1975)]. Rocks of the Tetelna Volcanics are considered to constitute the major phase of a late Paleozoic (dominantly Pennsylvanian) volcanic arc, whereas the Slana Spur Formation is interpreted to represent the waning stages of this arc. Richter and Jones (1973) suggested that this volcanic arc may have developed on oceanic crust and was subsequently added to the North American plate, whereas Bond (1973) postulated that the unexposed basement is of continental character.

The upper part, and probably much of the remainder as well, of the Talkeetna Mountains metavolcanogenic sequence is apparently of the same age as the post–volcanic arc Eagle Creek Formation. However, the metavolcanogenic sequence is very similar in lithologic composition to the slightly older Slana Spur Formation. These correlations suggest that the Talkeetna Mountains metavolcanogenic sequence probably represents the waning stages of a late Paleozoic volcanic arc system and that volcanism along this arc persisted longer in the Talkeetna Mountains than in the eastern Alaska Range.

TECTONIC SPECULATIONS

The recently mapped upper Paleozoic metavolcanogenic rocks in the Talkeetna Mountains indicate that remnants of a late Paleozoic volcanic arc system underlie considerably larger areas in southern Alaska than previously recognized.

According to Richter and Jones (1973), the late Paleozoic volcanic arc system may have formed on an oceanic plate in conjunction with southward subduction of the dominantly continental North American plate, which had a leading edge of oceanic crust. Most of the leading edge of oceanic crust had been consumed by Early Permian time (Richter and Dutro, 1975), and the volcanic arc began to collide with the continental part of the North American plate. The remnants of the volcanic arc were added to, and became part of, the North American plate, and the direction of plate subduction reversed by Early Triassic time. In the eastern Alaska Range, the zone of suture between volcanic-arc rocks and those of the continental North American plate coincides with the middle Tertiary right-lateral Denali fault.

In the central Alaska Range, the location of the suture zone is imperfectly known. A complexly deformed ophiolitic assemblage of serpentinite, gabbro, pillow basalt, bedded chert, and graywacke has been described by Clark and others (1972) from the

Upper Chulitna district in the west-central part of the range (Fig. 1). These ophiolitic rocks trend northeastward, as do all the upper Paleozoic and younger rocks of the Talkeetna Mountains, and have been interpreted by Clark and his coworkers to be Permian and Early Triassic in age. However, recent fossil determinations by D. L. Jones and others (in prep.) indicate that the ophiolitic rocks are of Tithonian and older Jurassic ages. The ophiolitic rocks of the Upper Chulitna district are herein interpreted to mark the suture zone. The Jurassic ages of the ophiolitic rocks indicate that the late Paleozoic to Jurassic rocks south of the suture zone have been added to the North American plate in post-Tithonian (probably Cretaceous) time. In view of the probable Cretaceous age of the suture, Richter and Jones' (1973) hypothesis on the development of the late Paleozoic volcanic arc may have to be modified.

The northeast structural trend of the Talkeetna Mountains region, including the trend of the postulated suture zone, is part of the large, northward-convex tectonic flexure of southern Alaska. This flexure has been interpreted by Grantz (1966) and Grantz and Kirschner (1976) to be the result of counterclockwise relative rotation—oroclinal bending—of southwest Alaska in late Mesozoic and early Tertiary time. An alternative hypothesis herein proposed is that the nearly right-angle bend is a reflection of the shape of the pre-Cretaceous continental North American plate against which the upper Paleozoic and younger rocks south of the postulated suture have been molded since late Mesozoic time. Evidence for a northward embayment in the pre-Cretaceous continental North American plate is not yet available. If the sharp flexure was an orocline, one would expect, assuming some brittle deformation, to find a system of radiating faults and joints, the outermost (northernmost) parts of which should have been pulled apart. None has been discovered so far.

In the eastern Alaska Range, Richter and Jones (1973) interpreted the Denali fault as a right-lateral strike-slip system, having been formed by northwestward plate motion in the northern Pacific since middle Tertiary time. In accordance with this concept, the western part of the arcuate Denali fault system, because it is nearly normal to the direction of plate motion, should splinter and change into a fault system of dominantly vertical displacement. Indeed, there is evidence of considerable vertical displacement along the western part of the fault (Reed and Lanphere, 1974). The postulated northward embayment in the continental part of the North American plate, into which younger crust is pushed along the eastern strike-slip part of the Denali fault system, suggests that at least some of this vertical displacement is caused by underthrusting from the southeast.

It is further speculated that the western part of the Denali fault system as shown by King (1969) is only one strand of a wide but not yet fully known zone of complex faults, chiefly high- and low-angle thrust faults. The recently proposed (Reed and Lanphere, 1974) 38 km of right-lateral displacement along the McKinley segment does not contradict the above speculation, because considerable horizontal movement can occur between slivers in such a fault zone. Another possibility is that this horizontal displacement is largely the result of interference by east-west tectonic compressional forces of western Alaska (Tailleur and Brosgé, 1970).

Recent mapping by Smith (1974) that disclosed several large faults branching off in a southwesterly direction from the apex of the Denali fault system tends to support speculations for a wide fault zone. Furthermore, ERTS-1 satellite multispectral imageries of the same general area show additional linear features, presumably faults, branching off also in a southwesterly direction. The general southwesterly direction of these structural features suggests that the speculated zone of thrusting roughly coincides with the postulated suture zone—a zone of structural weakness.

SUMMARY

The Pennsylvanian(?) and Early Permian metavolcanogenic rocks trending across the Talkeetna Mountains are interpreted to be remnants of a once-extensive late Paleozoic volcanic arc system which was added to the North American plate probably in Cretaceous time. The structural bend of southern Alaska, instead of being caused by oroclinal bending, may reflect the shape of continental rocks against which the upper Paleozoic and younger rocks have been molded. The western part of the Denali fault system, in contrast to its right-lateral eastern part, is speculated to be part of a complex and wide zone of thrust faults.

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