Cretaceous metamorphism in the northern Snake Range, Nevada, a metamorphic core complex

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CRETACEOUS METAMORPHISM IN THE NORTHERN SNAKE RANGE, NEVADA, A METAMORPHIC CORE COMPLEX

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ABSTRACT

In the northern Snake Range of eastern Nevada a decollement has placed Cambrian to Silurian sedimentary rocks on upper Precambrian to Cambrian metaclastic rocks and on plutonic rocks of uncertain age. In the southeastern part of the northern Snake Range a metamorphic event has produced garnet, staurolite, and kyanite in the lower-plate rocks of a metamorphic core complex. At the time of the metamorphism, monazite was formed and detrital zircon in the sands was strongly annealed.

Lead-uranium isotopic data for the monazite and for five different-sized fractions of the detrital zircon define a chord on a concordia diagram with the lower intercept representing an age of 78 ± 9 m.y. The upper intercept, which is controlled by the zircon fractions, indicates an average crystallization age of 1,726 ± 26 m.y. The intercept ages probably mean that the upper Precambrian to Lower Cambrian sands were derived from a crystalline terrane of early Proterozoic age and then were metamorphosed during the Late Cretaceous. Metamorphic micas recovered from lower-plate rocks of the Hampton Creek Canyon gave K-Ar dates as young as 21 m.y., which is probably a maximum age for the most recent movement along the overlying decollement in this area.

INTRODUCTION

The northern Snake Range of eastern Nevada, about 45 km long by 25 km wide, is one of more than 25 distinctive, isolated terranes known as metamorphic core complexes that are exposed in a narrow, sinuous belt from southern Canada into northwestern Mexico along the axis of the North American Cordillera (Coney, 1980b, fig. 1). More than half of these core complexes have been recognized only since 1970, and they are a subject of active interest today.

Coney (1980a, p. 3) defined Cordilleran metamorphic core complexes as "... a group of generally domal or archlike, isolated uplifts of anomalously deformed, metamorphic and plutonic rocks overlain by a tectonically detached and distended unmetamorphosed cover." Armstrong (1982) discusses both the unifying features of metamorphic core complexes of the Cordillera and the differences observed among these terranes. Of core complexes Armstrong (1982, p. 148) states: "Each has its own unique protolith and deformation history, and provides a new geological puzzle."

The northern Snake Range decollement has juxtaposed Cambrian to Silurian sedimentary rocks on upper Precambrian to Cambrian metaclastic rocks and on plutonic rocks of uncertain age (Hose and Blake, 1976, plate 1). The upper-plate rocks overlie the lower plate in a disharmonic fashion. Metamorphic micas exposed beneath the sole of the decollement gave K-Ar age results that place some limits on the time of most recent movement along the decollement, but heretofore the timing of other events in the northern Snake Range has remained problematical.

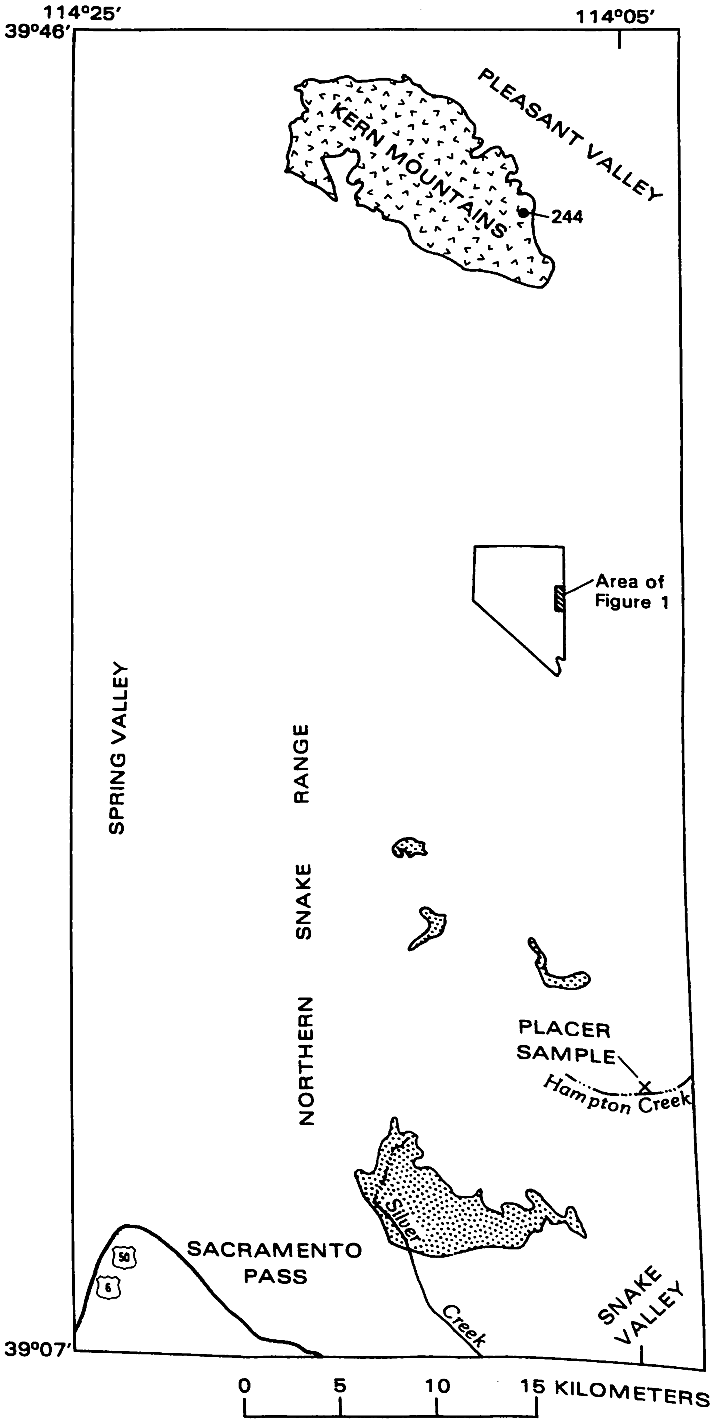

FIGURE 1. Map showing location of study area. Muscovite-phenocrystic two-mica granite of the Kern Mountains shown in checked pattern; intrusions of the northern Snake Range, stippled. Outlines of intrusions modified from Hose and Blake (1976).

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Here we present evidence bearing on the age of a metamorphic event that affected the lower-plate rocks of the Hampton Creek area of the northern Snake Range.

MATERIAL ANALYZED

Hampton Creek Canyon exposes a section through the southeastern part of the northern Snake Range metamorphic core complex (fig. 1). The Hampton Creek drainage (about 25 km²) is underlain mostly by lower-plate rocks, metaclastic rocks of late Precambrian and Early Cambrian age. Upper-plate rocks, mostly Cambrian limestone, rest on the higher parts of the drainage area. The stratigraphy and structure of both the upper- and lower-plate rocks have been intensively studied by Rowles (1982).

Kyanite, staurolite, and garnet formed in clastic rocks of appropriate composition during metamorphism of lower-plate rocks of the Hampton Creek area. This metamorphism has not been studied in detail, but the presence of staurolite and kyanite indicate that temperatures above 500°C were attained (Hietanen, 1967, fig. 1; Winkler, 1974, fig. 14–1).

More than 100 grams of monazite and 75 grams of zircon were recovered from a placer deposit near the mouth of Hampton Creek at 39°14′45″ N., 114°3′50″ W. The zircon grains are rounded and clearly have been through at least one cycle of sedimentation, indicating they were detrital in the unmetamorphosed equivalents of the upper Precambrian and Lower Cambrian metaclastic rocks that crop out in the Hampton Creek drainage. Although the zircons are detrital, it is also clear that the placer monazite was a primary metamorphic mineral in the Hampton Creek metaclastic rocks. The grains in the monazite fraction all appear nearly identical; the most common forms are egg-shaped, euhedral to subhedral crystals derived from faceted tablets parallel to (100). Such forms of a mineral of hardness 5 indicate that the monazite grew in place near the placer deposit and was not subjected to very much abrasion. Scattered grains of similar monazite were observed in samples of the Hampton Creek metasedimentary rocks during mineral separation work to recover micas for K-Ar age determination (Lee, Marvin, and Mehnert, 1980). Overstreet (1967, p. 16–20) has argued persuasively that monazite may be crystallized during the metamorphism of sedimentary rocks such as those discussed here.

ANALYTICAL RESULTS

Analytical results and model ages for the monazite and detrital zircon are listed in table 1. The Pb/U, $^{207}Pb/^{206}Pb$, and Pb/Th model ages for the monazite are somewhat discordant. This usually indicates that the isotopic systems have been disturbed subsequent to the formation of the mineral. In this case the disturbance might be attributed to the thermotectonic changes that occurred during the latter part of the Tertiary. However, the disturbance to the isotopic systems in the monazite was apparently minor since the Pb/U model ages are in fair agreement with the lower intercept age of the concordia diagram shown in figure 2. Similarly, the model ages for the zircon fractions show severe disturbance of the isotopic systems—probably as a result of the metamorphism that occurred during the Late Cretaceous. However, to some small degree, additional effects might be attributed to the Tertiary thrusting. The $^{207}Pb/^{206}Pb$ model ages strongly suggest a Proterozoic age for these zircons.

On the concordia diagram (fig. 2) the regression line for the metamorphic monazite and five fractions of the annealed detrital zircon defines a chord with a lower intercept of 78 ± 9 m.y. and an upper intercept of 1,726 ± 26 m.y. In

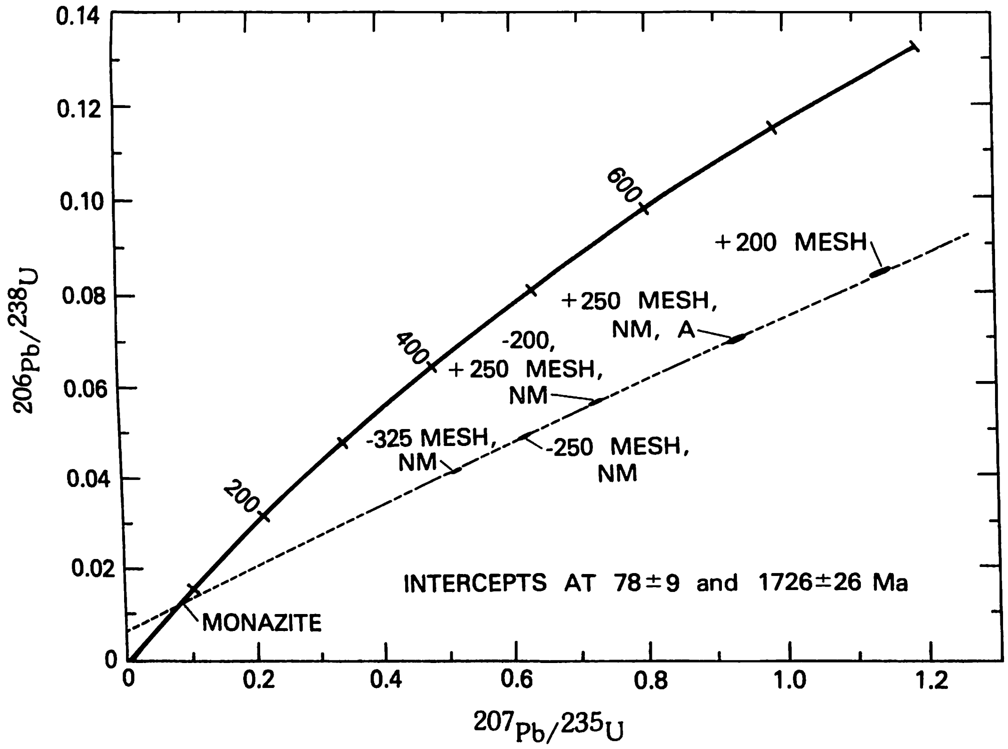

FIGURE 2. Plot of U-Pb data (table 1) showing error envelopes for samples included in this study. Points on the concordia diagram are labeled to correspond with the data in table 1: NM—nonmagnetic; A—abraded.

TABLE 1. Analytical data and model ages for monazite and zircon from a placer deposit at the mouth of Hampton Creek, northern Snake Range, Nevada

(NM = nonmagnetic; A = abraded; ND = not determined)

Fraction analyzed	Weight (mg)	U (ppm)	Th (ppm)	Pb (ppm)	^{206}Pb/^{204}Pb (measured)	Atomic abundance[1] (^{206}Pb=100)			Atomic ratios				Ages (m.y.)			
						^{204}Pb	^{207}Pb	^{208}Pb	^{206}Pb/^{238}U	^{207}Pb/^{235}U	^{207}Pb/^{206}Pb	^{208}Pb/^{232}Th	^{206}Pb/^{238}U	^{207}Pb/^{235}U	^{207}Pb/^{206}Pb	^{208}Pb/^{232}Th
Monazite																
Unseparated	4.01	6,184	32,904	215.3	1,601	0.0434	5.638	198.3	0.01314	0.09057	0.05001	0.00474	84.1	88.0	195.2	95.5
Zircon																
+200 mesh	14.97	549	ND	48.7	4,416	.0175	10.133	12.56	.08380	1.1430	.09892	ND	519	774	1,604	ND
+250 mesh (NM, A)	4.19	694	ND	51.9	1,236	.0494	10.463	13.83	.06941	.9360	.09781	ND	432	671	1,583	ND
−200, +250 mesh (NM)	8.70	769	ND	45.0	2,853	.0244	9.801	11.34	.05592	.7296	.09462	ND	351	556	1,520	ND
−250 mesh (NM)	10.37	943	ND	49.0	1,228	.0735	10.324	12.87	.04846	.6217	.09304	ND	305	491	1,488	ND
−325 mesh (NM)	10.65	1,118	ND	47.4	3,034	.0250	9.475	10.31	.04103	.5163	.09127	ND	259	423	1,452	ND

[1] Atomic abundance corrected for fractionation and blank. Pb blank = one nanogram; Pb fractionation correction = 0.15%/atomic mass unit.

order to check for possible lead loss, the +250 mesh, nonmagnetic zircon fraction was abraded by S. S. Goldich, U.S. Geological Survey, Denver, CO. The abraded core plots on line, indicating no recent lead loss. Thus the lower intercept indicates a minimum age for the monazite and a time of cooling (Late Cretaceous) following the metamorphic event. The upper intercept indicates the average age of the early Proterozoic zircons. Excluding the monazite, the regression line for the five fractions of annealed detrital zircon has intercepts of 71 ± 14 and 1,709 ± 35 m.y.

DISCUSSION

The concordia-intercept age (78 ± 9 m.y.) for the metamorphic event that affected the lower-plate rocks of the Hampton Creek area is very close to the 75 ± 9 m.y. crystallization age (sample 244, Lee, Stacey, and Fischer, 1985) determined for the muscovite-phenocrystic two-mica granite of the Kern Mountains, just beyond the northern end of the Snake Range and about 45 km north of the Hampton Creek area (fig. 1). The Kern Mounains intrusion crops out over an area of about 70 km² and is one of the strongly peraluminous muscovite-phenocrystic two-mica granites of eastern Nevada inferred to have been derived from a midcrustal source composed of Proterozoic metasedimentary rocks (Lee and Christiansen, 1983). The zircon-age data of Lee, Stacey, and Fischer (1985) show that the Kern Mountains pluton contains inherited zircon of early Proterozoic age (1,970 ± 330 m.y.), similar to the average 1,726 ± 26 m.y. old Hampton Creek zircon (fig. 2). Thus in the northern Snake Range-Kern Mountains area of northeastern Nevada there was Late Cretaceous magmatism and metamorphism involving materials derived from Proterozoic terrane.

A pluton about 30 km² in outcrop area and a few satellitic intrusions are present in lower-plate rocks of the northern Snake Range (fig. 1). The 30 km² mass was sampled in the Silver Creek area by Lee, Kistler, Friedman, and Van Loenen (1981), who described it as one of the equigranular two-mica granites of eastern Nevada. Three K-Ar ages determined on micas recovered from samples of the large pluton gave results ranging from 25.5 to 31.1 m.y. (Lee, Marvin, Stern, and Peterman, 1970; Lee, Marvin, and Mehnert, 1980), but these were regarded as spuriously young ages, reset by thermal stresses related to late movement along the overlying Snake Range decollement. The intrusions exposed in the northern Snake Range may be Cretaceous or even Jurassic in age (Lee, Stacey, and Fischer, 1985). In the southern Snake Range, within 15 km of the main northern Snake Range intrusive mass and 25 km of the Hampton Creek area, magmatic episodes of Jurassic, Cretaceous (79.1 ± 0.5 m.y.), and Tertiary ages have been recognized (Lee and Christiansen, 1983).

K-Ar ages have been determined on 15 micas recovered from samples of Cambrian metasedimentary rocks collected beneath the Snake Range decollement throughout the northern Snake Range (Lee, Marvin, and Mehnert, 1980). Results range from 20–22 m.y. for samples collected in the Hampton Creek drainage to as old as 55–57 m.y. for samples collected about 35 km northwest of Hampton Creek. Each of these ages was regarded (Lee, Marvin, and Mehnert, 1980) as a maximum age for the most recent movement along the overlying thrust fault in the area of the particular sample. In the area of Sacramento Pass, which divides the northern from the southern Snake Range, Hose and Whitebread (1981) have found geologic evidence that the decollement faulting took place at least as recently as 35 m.y. ago.

In addition to the Hampton Creek monazite, scattered grains of similar monazite were found in the heavy mineral fractions recovered from samples of upper Precambrian and Lower Cambrian quartzites collected over an area of 3,500 km² in eastern Nevada. Aside from the monazite grains, the only other metamorphic minerals present in most of these quartzites are muscovite and biotite (Lee, Van Loenen, Brandt, and Doering, 1980). Future uranium-thorium-lead isotope age work on metamorphic monazite grains recovered from these upper Precambrian and Lower Cambrian quartzites will help to unravel the history of this region.

CONCLUSIONS

The sediments that became the upper Precambrian and Lower Cambrian metaclastic rocks of the northern Snake Range metamorphic core complex were derived from an early Proterozoic terrane that crystallized about 1,700 m.y. ago. During a metamorphic event that affected lower-plate rocks of the Hampton Creek area about 80 m.y. ago, staurolite, kyanite, and garnet were formed. At the same time detrital zircon in the clastic sediments was strongly annealed. Apparently metamorphic monazite also crystallized at the time of the 80 m.y. event. However, the possibility exists that this metamorphic monazite formed at an earlier time and was only recrystallized about 80 m.y. ago. Future work on similar metamorphic monazite present in lower grade upper Precambrian and Lower Cambrian metasedimentary rocks far outside the Hampton Creek area will help us to understand the metamorphic history of the Snake Range.

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