Interpretation of structural geometries of the King Peak subterrane from Telegraph Creek to Miller Flat, Northern California

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INTRODUCTION

The tectonic history of the King Range terrane of northern California is the subject of much debate. Previous workers have divided the terrane into two subterranes, the King Peak subterrane, and the Point Delgada subterrane (fig. 1). The Point Delgada subterrane is composed of eastward dipping basaltic pillow lava, pillow breccia, and arkosic sandstone turbidites from the late Createaceous (McLaughlin et al, 1982). These are structurally overlain by the middle Miocene graywackes and argillites of the King Peak subterrane. Due to the rugged nature of the King Range and lack of good exposures, only a limited amount of work has been done in the King Peak subterrane. Data from previous work come mostly from the northern parts of the King Peak subterrane, and have been interpreted to indicate that the subterrane was obducted during NNE-directed thrusting (McLaughlin et al, 1982, Beutner, 1972).

My project examined coastal exposures in the central portion of the King Peak subterrane. The purpose of the study was to interpret the structural geometries, to reconstruct the deformational history, and to develop a tectonic model for the evolution of the King Peak subterrane in the area which I worked. This work may help to clarify the history of the King Range terrane as a whole and to fit the evolution of the terrane into the broader framework of California tectonics.

My field area extended from Telegraph Creek, which marks the northern end of Point Delgada, northward to Big Flat Creek (fig. 1). The rocks in my field area consist of unmetamorphosed, fine-grained graywacke, and mudstone to siltstone argillites. The graywackes range from massive to thinly laminated beds of turbidites. All of these rocks have been deformed by the complicated tectonics associated with subduction, the passage of the Mendocino Triple Junction, and finally, San Andreas-related dextral movement.

GEOLOGIC SETTING

The King Peak subterrane consists of rocks which originated in the accretionary wedge of the Cascadia subduction zone approximately 15 mya (McLaughlin et al, 1982). Since that time, as the San Andreas Fault has continued to lengthen, the Mendocino Triple Junction has passed northward from southern California to its present position near Cape Mendocino. resulting in a change from a subduction environment to a dextral transform environment. The King Range is now within the San Andreas Fault Zone, although the exact trace of the fault is not clear. The passage of the triple junction has led to uplift rates of 1-5 m/ ka in the King Range terrane (Dumitru, 1991, Merritts et al, 1989, and McLaughlin et al, 1983).

FIELD AND LABORATORY METHODS

The field portion of this project entailed measuring and recording all structural data at available outcrop along the coast and up stream valleys. Attitudes of bedding, folds, faults, and rock fabric were measured, and relationships between all of the structures were noted. Oriented samples of fold hinges and fault gouge were collected for thin section analysis.

Structural data from the field were compiled in several ways. Using Adobe Photoshop and Canvas, all field data were compiled onto a USGS map of the area. All measurements of planes and lines were compiled and analyzed using the Stereonet program of R. W. Allmendinger.

STRUCTURAL GEOMETRIES

Bedding: Generally, bedding trended NNW and dipped to the ENE, coplanar with the axial surfaces of the first generation of folding. Bedding is generally very discontinuous, and stratigraphic markers are absent, so correlation of the stratigraphic sequence throughout the study area was not possible. Within some of the graywacke beds there is development of phacoids and extension veins which are generally perpendicular to bedding.

Folds: Two generations of folding were evident in the field. The first generation (F1) was characterized by isoclinal folds with a prevailing counter-clockwise rotation sense. F1 folds are overturned to the southwest, with hingelines trending mainly N and axial surfaces which dip to ~50-70° ENE (fig 2). The later period of folding (F2) can be seen refolding the first generation in several places. F2 folds are characterized by open folding of layers with poles to axial surfaces which generally plot in the S to SW quadrant (fig. 2).

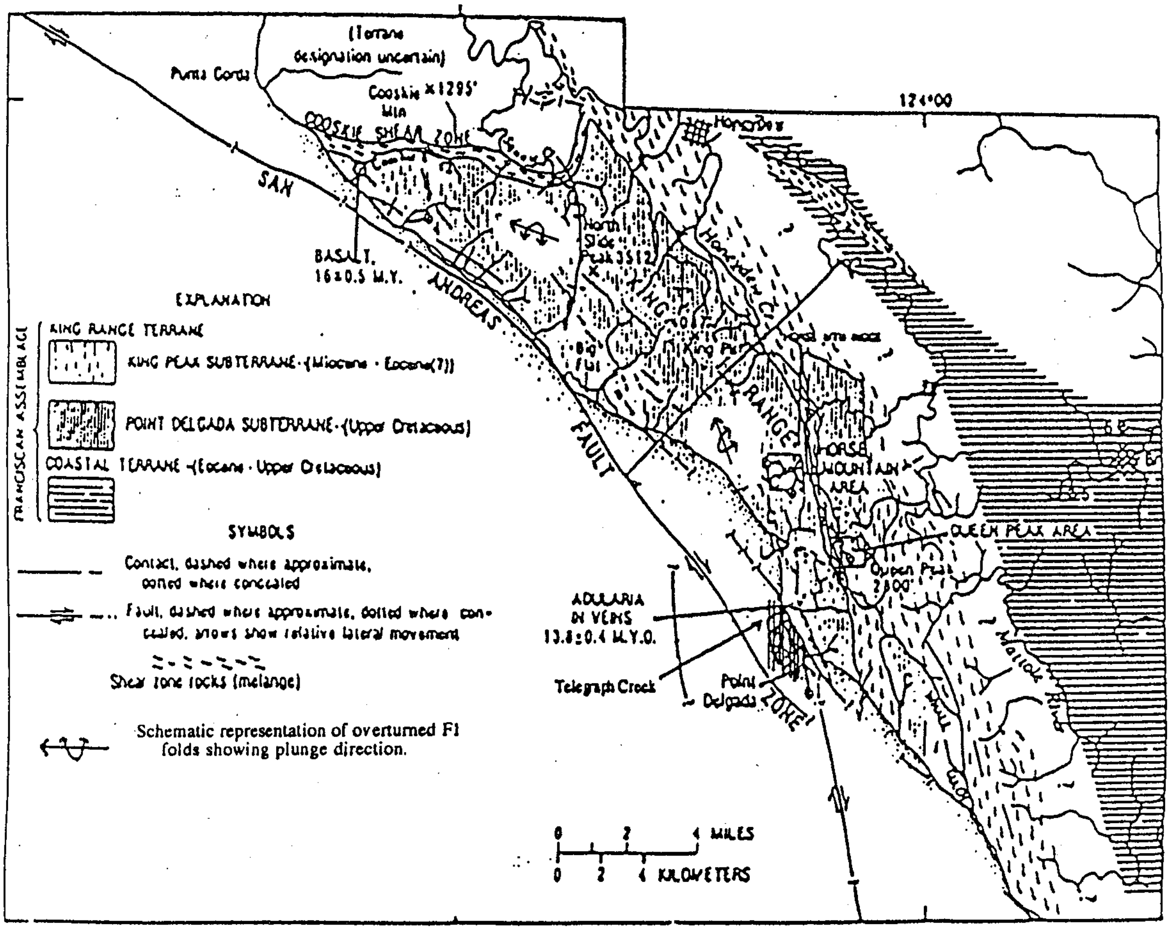

Fig. 1. Generalized geology of the King Peak subterrane and surrounding areas (Modified from McLaughlin et al, 1982).

Faults: Several generations of faults outcrop in my field area. The oldest generation of faulting is characterized by eastward dipping fault surfaces, which outcrop mainly as thin fractures and in places display mineralized fault gouge. In some places these faults offset the first generation of folding, but elsewhere the faults are not continuous through the folds. This may mean that there were actually two periods of faulting within what I have identified as the first generation of faults, one prior to F1 folding and one after. Alternatively, this may indicate that this first generation of faulting was contemporaneous with F1 folding (fig. 3). Interpretations are hampered by poor outcrop exposure and the shattered nature of the rocks. A second generation of faulting can be seen in some of the outcrops. Where shear sense can be determined, these faults appear to have top-to-the-northwest displacement. A third generation of faulting is distinguished by zones ranging from 3-40 cm in width filled with grayish, unconsolidated, moist gouge. These faults trended northwest with dips to the northeast, and in some places showed evidence for reverse offset (fig 4). Crosscutting every other outcrop feature, these faults are constrained in age by the fact that they do not cut the Holocene platforms which are present in the field area.

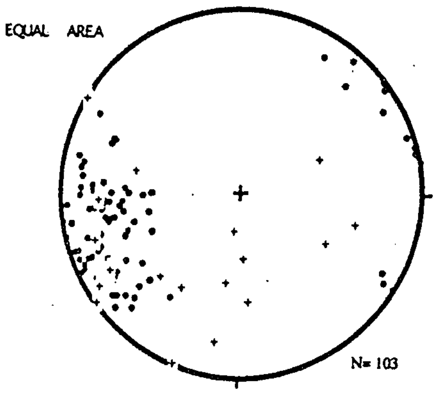

Fig. 2. Poles to planes of axial surfaces

• F_1

+ F_2

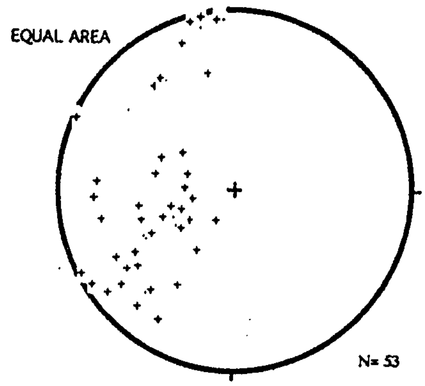

Fig. 3. Poles to planes of first generation faults

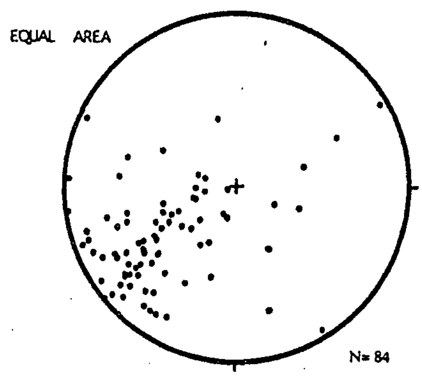

Fig. 4. Poles to planes of third generation faults

DISCUSSION

The structural geometries of the King Peak subterrane from Telegraph creek north to Miller Flat, seem to indicate a classic accretionary prism setting. The lack of metamorphism and highly deformed nature in the rocks indicate that these sediments were originally at the top of the prism. The northwest-striking, east-dipping faults which I have identified as first generation, represent imbricate thrust faults which are generally synthetic to the subduction zone and are characteristic of accretionary prisms. Movement along these faults created the isoclinal, counterclockwise rotated, F1 folds which are overturned to the southwest (fig. 5). With the continuation of subduction, a shear fabric which indicates top towards the subducting plate is formed due to the regional strain caused by subduction. The second generation of faulting, which indicates a top to the NW sense of displacement, is interpreted to be related to this strain. The open grouping of poles to axial surface of F2 folds in the southern quadrants may indicate that the folds originated during the passage of the triple junction. The third generation of faulting may have been the result of uplift of the King Range during the passage of the triple junction, either due to the effects of the slabless window, or regional space problems associated with the termination of the San Andreas Fault.

These structures and interpretations are different from those documented further north by previous workers (Beutner, 1972, Beutner et al, 1975, McLaughlin et al, 1982). The same generations of folding and faulting have been identified by these workers, but the first generation folds were interpreted to be related to obduction processes instead of subduction (McLaughlin et al, 1982). This interpretation was based on the first generation folds which were overturned to the NNE, with axial surfaces dipping SW, in contrast with the F1 folds in my area which were overtuned to the SSW, with axial surfaces dipping NE. This difference in fold geometries might be explained by any of several different models. 1: A change along strike of the convergent margin from subduction to obduction (landward vergence), separated by a tear fault. In order to initiate landward vergence a combination of low basal shear stress, an arcward dipping decollement, and a strong wedge are needed (Mackay, 1995). In the King Range, the change from subduction to landward vergence could have been caused by a local increase in sediment deposition rate at different places along the coast, which could have increased pore pressure and lowered the basal shear stress. 2: An increase in wedge thickness, and time-progressive, top-to-the-east rotation of the wedge (fig 5). 3: A combination of both offscraped sediment and subducted sediment, due to an arcward dipping thrust fault within the subduction complex (fig. 6).

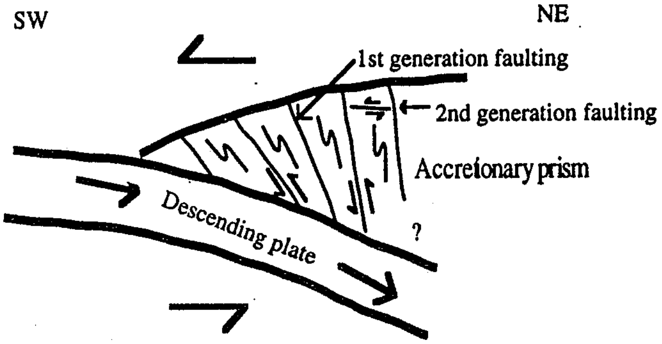

Fig. 5. Cartoon drawing of an accretionary prism showing development of F1 folds, as well as the first generation faults and second generation shears. Time progressive rotation of the wedge is also illustrated.

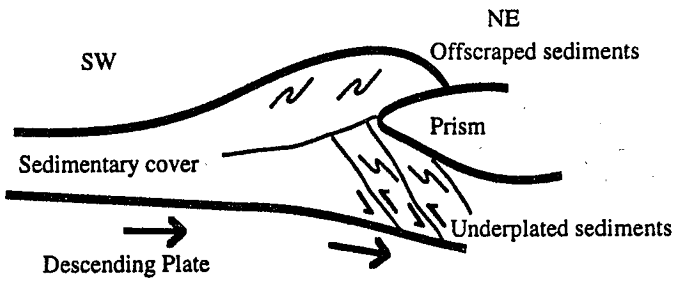

Fig. 6. Cartoon drawing depicting a combination of both Offscraped sediments and subducted sediments.

CONCLUSIONS

The King Peak subterrane from Miller Flat, south to Telegraph Creek originated in the accretionary wedge of a subduction complex, and was subsequently uplifted due to the passage of the Mendocino Triple Junction or regional space problems. While my field area shows the classic structures of subduction-related tectonics, other parts of the King Peak subterrane indicate different styles of tectonics. These differences can be explained by several different models, but until more structural data are collected and compiled for the entire King Peak subterrane, the answer remains uncertain.

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