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Preliminary tectonostratigraphic terrane map of California

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Introduction

The concept that much of the Cordillera of western North America is made up of originally separate allochthonous tectonostratigraphic terranes is based largely on stratigraphic, structural, and geophysical data obtained during the past 5 years or so (Coney, Jones and Monger, 1980; Jones and others, 1982). Many of these new data have not yet been published, or are available only piecemeal in various scattered scientific journals or in open-file reports (Jones and others, 1981) of the U.S. Geological Survey and the Geologic Survey of Canada. The purpose of this map with accompanying columnar sections and brief text is to make available in preliminary form information on the distribution, character, and age of the various tectonostratigraphic terranes of California.

Terrane Definition

Terranes are fault-bounded geologic entities of regional extent, each characterized by a geological history that is different from the histories of contiguous terranes. Ideally, such histories are determined from the stratigraphic succession preserved in a terrane, but in some cases such histories are largely or completely destroyed by tectonic or sedimentological disruptions or by metamorphic overprinting (e.g. Baldy terrane in southern California). In the latter cases the disruptive or metamorphic event itself may characterize the terrane. In addition, some terranes are composite entities produced by amalgamation of two or more terranes into a single terrane. In cases where juxtaposed terranes possess elements of coeval stratal units, one must demonstrate different and unrelated geologic histories as well as the absences of intermediate lithofacies that might link the two terranes. The basic question that must be asked while analyzing stratigraphic sequences of possibly distinct terranes is whether or not the inferred geologic histories are compatible with the present spatial relation. This decision is not always easy to make, and is heavily dependent on the quality and quantitiy of geologic controls that are available to the analyzer. The degree of differences noted between terranes is thus variable, and classifications will differ according to the judgement, experience, and competency of the analyzer. New data always require reexamination of existing terrane classifications, and it is expected that new combinations or subdivisions will result from additional paleontologic, geologic, and geophysical research in California. In this regard, terrane nomenclature is similar to stratigraphic nomenclature, and is subject to continuous revisions as data accumulate and concepts evolve. Terranes are conveniently categorized into four general types (1) stratified, (2) disrupted, (3) metamorphic and (4) composite; examples of each are discussed below.

1. Stratigraphic terranes: These terranes are characterized by coherent stratigraphic sequences in which depositional relations between successive lithologic units can be demonstrated. Basement rocks may or may not be preserved. Rock sequences within stratified terranes may be subdivided into threee broad categories (some terranes have passed through successive tectonic phases encompassing two or three of these categories):

   a. Fragments of continents: These terranes are represented by the presence of a Precambrian basement with an overlying sequence of shallow-water sedimentary rocks of Paleozoic and Mesozoic ages. Included are sedimentary rocks of continental derivation that are detached from their basement substratum. Examples include the Salinia and Tujunga terranes of central and southern California.

b. Fragments of oceanic basins: These terranes are charcterized by sequences of mafic and ultramafic rocks characteristic of oceanic crust with overlying deep-sea sedimentary deposits, e.g. the Elder Creek and Smith River terranes. Both have ophiolitic basements and deep-sea sediments, yet younger strata in both indicate continental margin depositional environments.

2. Disrupted terranes. These terranes are characterized by blocks of heterogeneous lithology and age, usually set in a matrix of sheared shale, flysch, or serpentinite. Most of these terranes contain fragments of ophiolitic rocks, blocks of shallow water limestone, deep-water chert, and packages of graywacke with lenses of conglomerate; in addition, some disrupted terranes contain blueschists as exotic blocks or as a regional metamorphic overprint. Examples include the Central Franciscan and Rattlesnake Creek terranes.

3. Composite terranes. These terranes are composed of two or more distinct terranes that became amalgamated and subsequently shared a common geologic history prior to their accretion to North America. An example of an amalgated terrane is the Salinia-Tujunga-Stanley Mountain-San Simeon terrane amalgam that composes the Santa Lucia-Orocopia allochthon of southern California.

4. Metamorphic terranes. These terranes are characterized by a regional, terrane-wide penetrative metamorphic fabric and development of metamorphic minerals to such a degree that

original stratigraphic features and relations are obscured. In addition to metamorphic differences, protolithic contrasts with adjoining terranes also must be demonstrable. Examples include the Pickett Peak, Ft. Jones, and Baldy terranes.

Size of Terranes

The terranes of California vary enormously in size. Some are on the order of hundreds of square kilometers whereas others cover only a few square kilometers or less. A few terranes are not now continuous bodies, but consist of separate, disjunct blocks that can be unequivocally correlated. The Laytonville Limestone, too small to show on the present map is distributed as isolated blocks throughout the Central terrane in northern California (Alvarez and others, 1980).

Terrane boundaries

By definition, all terranes must be separated from adjoining terranes by major faults, fault zones, or complex sutures. In practice one may be confronted with two nearby areas with different stratal units yet the boundary conditions are not known. In such cases the most conservative tack is to assume a fault until other linking relations can be demonstrated.

Confusion may arise in discriminating between fault bounded terranes and successive tectonic elements within a particular terrane. For example, in our definition, the development of a volcanic arc assemblage on top of an earlier-formed sedimentary or igneous package does not constitute formation of a new terrane. This definition is crucial to terrane analysis and failure to discriminate between terranes and contrasting lithogenetic elements within terranes is a potential source of confusion.

Amalgamation to form composite teranes: Two similar but unrelated events in the history of terranes should be distinguished. An early event referred to as amalgamation, is the joining together of separate terranes to form a composite terrane prior to the addition of the amalgamated terrane to a cratonal margin. The later event, termed accretion is the collision and welding of a terrane (either composite or individual) to the craton. These events may be widely separated in time, or closely follow one other. Timing of amalgamation and accretion can be established by three main criteria:

1) overlap assemblages that depositionally overlie two distinctive, juxtaposed stratigraphic sequences (e.g. the Cretaceous deposits (K) of the northern Sacramento Valley that link the terranes of the southern Klamath Mountains and the Cenozoic deposits (QT) through most of California; 2) sudden appearance of detritus in one terrane derived from its dissimilar neighbor (e.g. granite boulders in paralic facies of the Stanley Mountain terrane indicate an Upper Cretaceous suturing to the Salinia terrane); 3) welding together of unlike sequences by granitic intrusions (e.g., the map depicts late Mesozoic plutons that stitch all the terranes in the central Sierra Nevada region).

By means of a flow chart we can schematically depict successive amalgamation stages of a variety of terranes. Fig. 1 demonstrates the suturing events in Southern California. In this instance episodes of accretion and amalgamation are inferred from the geologic relations of overlap sequences, plutonic intrusions or debris from a distinctive provenance.

Post accretionary dispersion: The main period of accretionary activity ended about Middle Miocene time in California. This has been followed by a long and still poorly known history of complex strike slip faulting, folding, and thrust faulting related to the San Andreas system. The dispersion of terranes by the San Andreas fault system can clearly be seen in the San Francisco Bay region and along its trace in southern California. It is also quite clear that many of the presently active strands of the San Andreas Fault system are following older accretionary sutures.

Figure 1. Generalized stratigraphic columns of presently contiguous terranes in southern California showing inferred ages of amalgamation and accretion.

References

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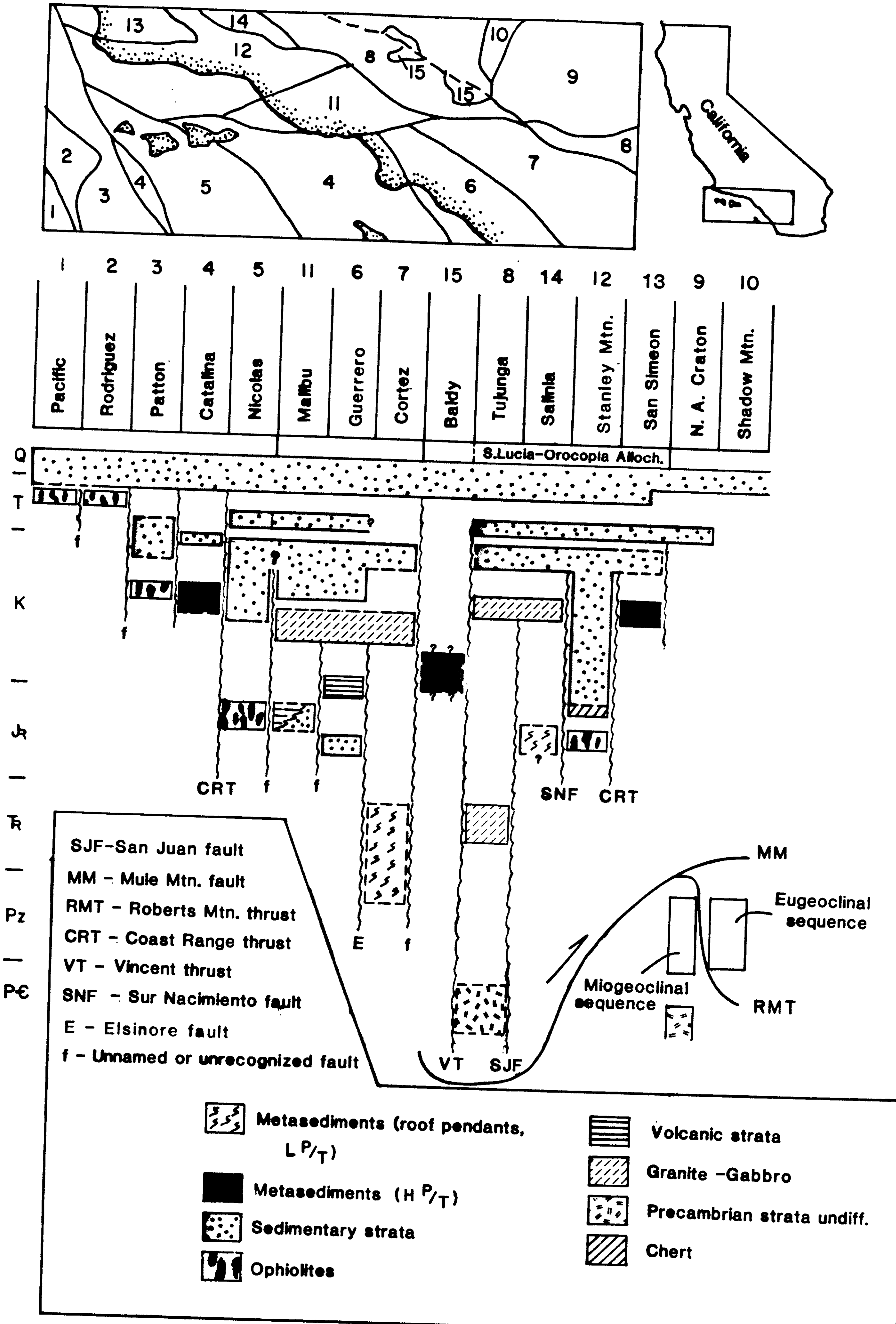

California
1 2 3 4 5 11 6 7 15 8 14 12 13 9 10
Pacific
Rodriguez
Patton
Catalina
Nicolas
Malibu
Guerrero
Cortez
Baldy
Tujunga
Salinia
Stanley Mtn.
San Simeon
N. A. Craton
Shadow Mtn.
S.Lucia-Orocopia Alloch.
Q
T
K
Jr
Tr
Pz
P€
f
CRT
SNF
E
VT
SJF
MM
RMT
Eugeoclinal sequence
Miogeoclinal sequence
SJF-San Juan fault
MM - Mule Mtn. fault
RMT - Roberts Mtn. thrust
CRT - Coast Range thrust
VT - Vincent thrust
SNF - Sur Nacimiento fault
E - Elsinore fault
f - Unnamed or unrecognized fault
Metasediments (roof pendants, L P/T)
Metasediments (H P/T)
Sedimentary strata
Ophiolites
Volcanic strata
Granite -Gabbro
Precambrian strata undiff.
Chert