A Characterization of the Point Delgada Tectonostratigraphic Terrane

Erin Gorman
Department of Geology, Smith College, Northampton, MA 01063-0100
Facualty Sponsor: Robert Burger, Smith College

INTRODUCTION

During the Late Jurassic to the Late Cretaceous the Pacific plate was subducted beneath the North American plate. The resulting accretionary wedge was sutured to the western North American continental margin and is known as the Franciscan Complex. Franciscan outcrops extend as far south as Mexico and as far north as Oregon. This complex is a complicated sequence of volcanic, plutonic, low temperature, high pressure metamorphic, and sedimentary rocks which include shale, sandstone, minor conglomerate, minor limestone.

PURPOSE

Analysis of the Franciscan Complex was undertaken at Point Delgada located approximately 200 miles north of San Francisco along the northwestern coast of California in order to determine if the rocks present at this location represent a mélange or an olistostrome. A second goal is to compare Point Delgada rocks to other Franciscan exposures along the San Andreas fault to determine if Point Delgada has been transported north from its original location of emplacement due to movement along the San Andreas.

GEOLOGIC SETTING

Throughout the Mesozoic the western continental margin of North America experienced extensive tectonic activity. The western margin expanded due to the suturing of exotic terranes to the preexisting continent. During the Early to Middle Triassic the American western margin was a passive margin, but in the Late Triassic a subduction zone was established along the margin. At various times throughout the Mesozoic several separate subduction zones were active simultaneously (Stanley, 1989). These composite subduction processes caused island arcs and ocean floor sections to collide and be accreted to the continent, thereby increasing continental landmass. These sections of accreted ocean floor and island arcs are called exotic terranes.

Today the Mendocino triple junction is located in northwestern California and represents the present day continuation of the complex tectonism that originated in the Mesozoic. The triple junction is located onshore in northwestern California, and is comprised of the intersection of the Gorda plate, the Pacific plate, and the North American plate (McLaughlin, 1991). The plate boundaries that compose the Mendocino triple junction are the Cascadia subduction zone, the Mendocino fault, and the San Andreas fault (McLaughlin, 1991).

METHODS

The rocks exposed in the southern half of Point Delgada were sampled, photographed, and described in detail, beginning at Shelter Cove and working northward towards Telegraph Creek. As both volcanic and sedimentary rocks are present along this stretch of coast, the relationships between them were investigated paying close attention to exposed contacts, rock composition, shear fabric, faulting, and folding. Within the terrigenous sedimentary rock units an effort was made to differentiate between the presence of a tectonic melange or an olistostrome. Rock samples were collected for thin section analysis so rock compositions and deformation mechanisms could be studied in detail.

The predominant rock type present along the southern half of Point Delgada is terrigenous sandstone. Point counts of twelve sandstone thin sections were conducted to determine if the sandstones all share a similar source area.

Shelter Cove, the southernmost extension of the field area, contains volcanic rocks. Thin sections and hand samples have proved unrevealing as to whether these rocks are volcanic sedimentary or undisturbed volcanic flows, and if there is any correlation between the volcanic rocks south of the Point and those located further north. Investigation of these enigmatic rocks using a scanning electron microscope is being considered in the hopes that more definitive information can be obtained.

A literature search is presently being conducted in an effort to discover similar Franciscan outcrops along the San Andreas fault that might suggest movement along the San Andreas fault after accretion of Point Delgada to the North American continent.

GENERAL GEOLOGY

The predominant rock types exposed along the southern section of Point Delgada are intermixed sandstone and shale. In hand sample the sandstones are chiefly medium to coarse grained, contain muscovite mica, quartz and feldspar, and are green-gray or yellow-brown in color. The sandstones contain similar mineral assemblages implying the color differences must be caused by different weathering conditions. Many of the samples are veined with calcite and/or quartz and are generally highly fractured in hand sample.

Alternating light and dark gray shale layers are present. It is not unusual for the layers to contain several different generations of calcite veins. The majority of the shale has been sheared and its internal structure completely destroyed.

Massive sandstone blocks truncated by shale shear zones represent typical field relations at the southern section of the Point as a whole. Facing directions were determined on several large sandstone blocks, only to find that the blocks had been disturbed from their original horizontal layers and are now just incoherent blocks with no identifiable stratigraphic relation to each other. In some places intact lenses of shale are floating within the sheared shale. Within these intact shale lenses soft sediment deformation features are preserved.

Investigation of thin sections allow the sandstones at Point Delgada to be classified as quartz or sublithic arenites (Fig. 1). They are composed of quartz, plagioclase feldspar, chlorite, sericite, and lithic grains. These minerals comprise an acknowledged arenite mineral assemblage where the sandstone compositions are chiefly quartz grains, with less than 15% matrix and less than 5% rock fragments and feldspar (Carozzi, 1993; Tucker, 1991). The lithic grains are predominantly graywacke, but granitic rock fragments are also present. The arenites are composed of poorly sorted, angular grains. Although some quartz grains are fractured, less than 25%, the majority of the thin sections do not demonstrate any deformation features. None of the thin sections exhibit offset or shearing. This suggests that no deformation occurred subsequent to lithification.

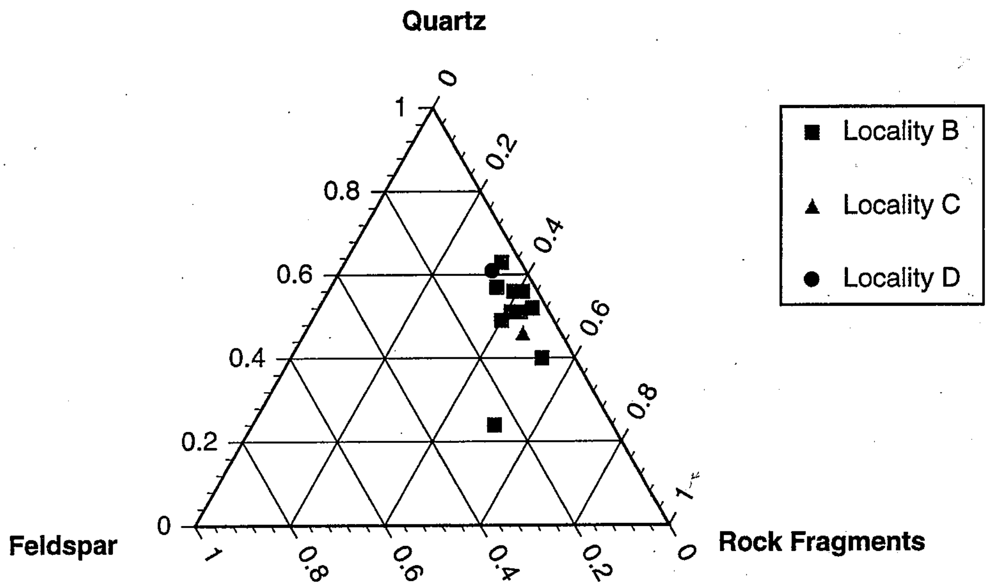

Figure 1. Ternary diagram illustrating the similarities in compostion of sandstones collected along the southern section of Point Delgada.

There are volcaniclastic rocks exposed at Shelter Cove in the southernmost extension of the field area. After close inspection, the rocks seem to be sedimentary with a mafic volcanic source. They appeared to have formed on the seafloor due the fact that they are extremely fine grained and contain abundant, well-developed calcite veins, suggesting slow sedimentation rates and access to a calcium-rich environment. The low grade metamorphism is hypothesized to be the result of some kind of seafloor metamorphism, such as hydrothermal or burial metamorphism, rather than subduction. Vesicles within the rocks are lined with oxides, prehnite, or serpentine. The rocks at Point Delgada contain zeolites, although no lawsonite or pumpellyite are present. These rocks also contain both quartz and calcite veins. Tentatively, these rocks are being referred to as volcaniclastic rocks (well-cemented volcanic tuffs) that formed due to the slow deposition of fine-grained volcanic material on the seafloor bottom.

This study has attempted to characterize the rocks present at Point Delagada as a mélange or an olistostrome.

Mélanges are chaotic rock bodies formed along convergent plate boundaries and are due to fragmentation and mixing of resistant blocks within a ductile matrix. The lithology of mélanges is predominantly interbedded shale and sandstone containing native and exotic blocks of chert, limestone, serpentinite, and green or blue schist blocks (Page, 1977). They are pervasively sheared units with schistose matrices, exotic clasts, and resistant phacoids of native material (Raymond, 1984). Shears and fractures slice both the matrix and the clasts. Contacts are tectonic (Hsu, 1974).

Olistostromes are defined as sedimentary units composed of rounded clasts in a sandy or pelitic matrix. They generally form due to slumping or sliding and can contain preserved or obliterated bedding (Raymond, 1984). An olistostrome can contain clasts within an argillaceous matrix. The clasts are derived from the underlying formation although not the overlying unit (Page, 1978). Olistostromes posses shale and sandstone lithologies similar to mélanges.

It is extremely important to differentiate between a mélange and an olistostrome, because they can potentially lead to completely different geologic interpretations. Mélanges imply tectonic processes created and deposited the rock unit, suggesting that the exposure was formed at or along a tectonically active border. The presence of an olistostrome suggests that the rock unit formed due to sedimentary processes, devoid of tectonism. Any shearing that occurred that affected an olistostrome occurred after deposition. If a mélange is a tectonic feature and an olistostrome a sedimentary feature then the very presence of one rather than the other implies a completely different genetic histories for the terrane. Much of the confusion in identifying mélanges and olistostromes is that they have several characteristics in common. Both are chaotic rock bodies that have been transported and redeposited away from the original area of deposition. Mélanges and olistostromes possess large and small (usually rotated) fragments of ophiolite and sedimentary rocks within an argillaceous matrix (Page, 1978). Soft sediment deformation features such as convolute laminae can be seen in both olistostromes and mélanges. If an olistostrome has undergone tectonism and is pervasively sheared, most of the sedimentary contacts and characteristics would be destroyed, and it would be next to impossible to differentiate it from a mélange.

DISCUSSION

It is difficult to establich whether the southern section of Point Degada is composed of predominantly mélanges or olistostromes that have experienced intense deformation. No original sedimentary contacts were identified in the field suggesting that the southern half of the Point is chiefly composed of mélanges. However, close inspection of sandstone thin sections revealed no evidence of deformation subsequent to lithification except for a few cracked quartz grains and minor pressure solution. The lack of shearing and offset in the thin sections is suggestive of olistostromal origin. At one outcrop a volcanic-sedimentary contact is exposed which suggests depositional rather than tectonic contact between the two rock bodies.

Three locations where the Franciscan Complex outcrops along the San Andreas fault have been identified as potentially representing transported terranes similar to Point Delgada; Bolinas Ridge, San Bruno Mountain, and Loma Prieta (Underwood et al., in press). A literature search is currently underway to attempt to correlate these Franciscan outcrops.

The sandstone and shale sequences along the south of the Point are apparently non-diagonistic, so the volcaniclastic rocks may prove to be the key to correlating Point Delgada to Bolinas Ridge, San Bruno Mountain, and Loma Prieta, and to determine if Point Delgada rocks have been displaced due to movement along the San Andrea fault. However, recent investigations do not support the theory that Point Delgada is a transported terrane (Underwood et al., in press). Hopefully, this current research will help to prove or disprove this transport theory.

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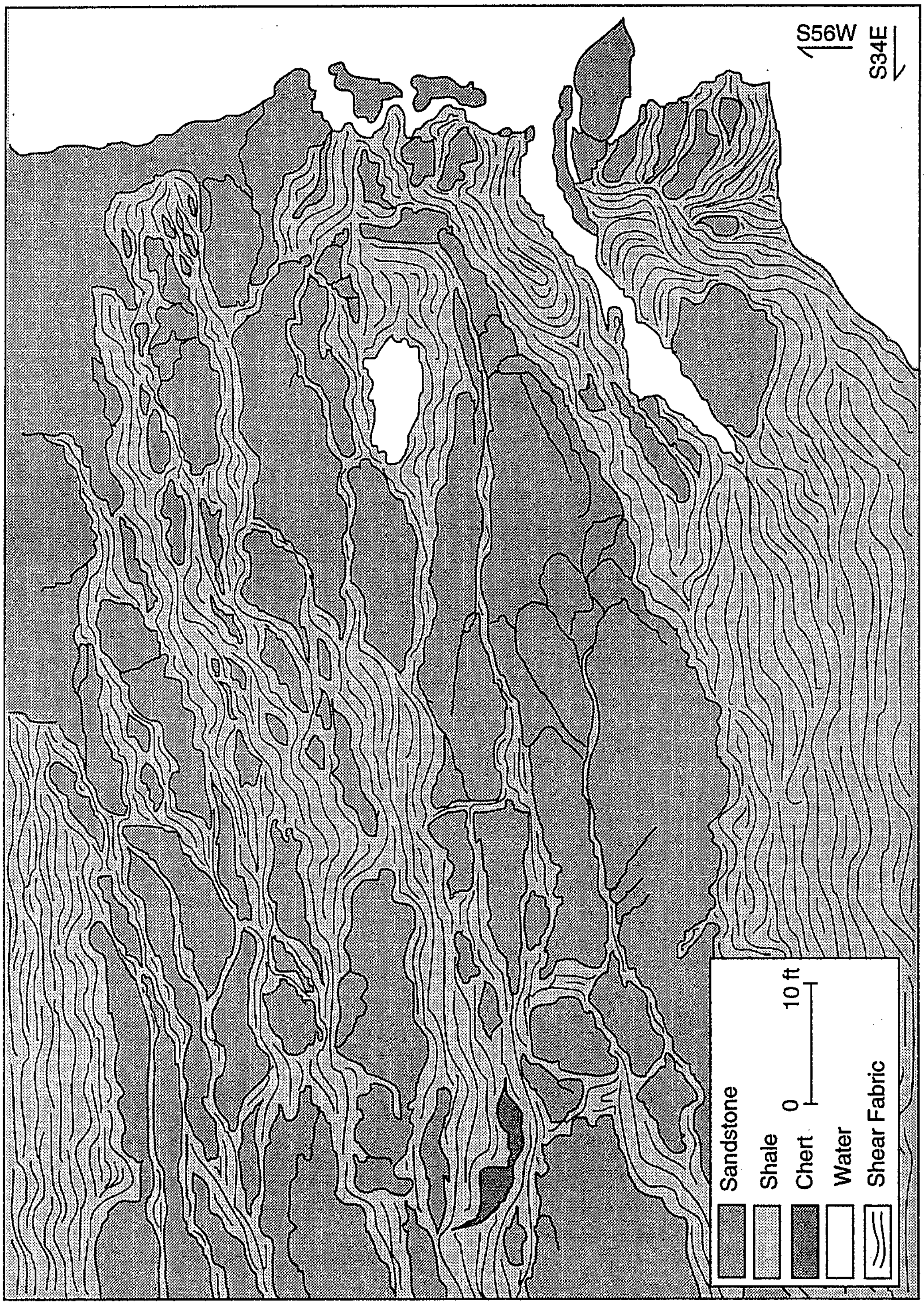

Figure 2. Outcrop map illustrating mélange texture.