Origin of Blueschist-Bearing Melange at San Simeon, Central California Coast Ranges

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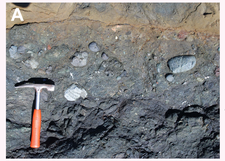
1 Introduction

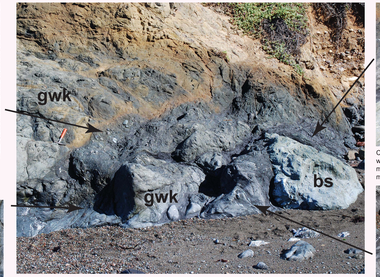
Melanges at San Simeon have been interpreted as deformed olistostromes (Cowan, 1978) or as subduction-channel flow melange (Cloos, 1982). I distinguish seven types of melange, with transitions among them, all of which contain exotic clasts of greenstone, chert, and blueschist. (1) bedded conglomerate, (2) structureless conglomerate, (3) pebbly mudstone, (4) sandy block melange, (5) broken formation, (6) mud-matrix melange without deformational fabric, (7) sheared melange. Transitional types suggest that types (1) to (3) are sedimentary in origin, and that types (4) to (6) formed by disruption of poorly consolidated sediment, either on the trench slope or at very shallow levels in the accretionary wedge. Sheared melange (7) was formed by low-temperature post-consolidational deformation of all other types, which produced shear bands and a crude fabric transitional between slaty cleavage and gouge fabric. I suggest that the disrupted character of the melanges formed primarily by sliding down the trench inner slope of unconsolidated sediment, including clasts and blocks of previously accreted and exhumed greenstone, chert, and blueschist. The deformational fabric in the shear melange is largely unrelated to the disruption, and was formed late in the history of the accretionary wedge.

2 An Association of Melange Types

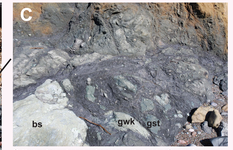


A. Pebbly mudstone with rounded pebbles of plutonic and volcanic rocks derived from the Salinia terrane.

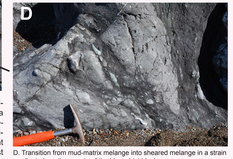
B. Deformed pebbly mudstone in a shear zone forms sheared melange typical of much of the San Simeon exposures



Undeformed *pebbly mudstone* (A) lies in unfaulted contact with a large block of graywacke sandstone (gwk). The relationship is clearly depositional. The pebbly mudstone is deformed in a shear zone to form *sheared melange* at (B). The pebbly mudstone passes into *mud-matrix melange* at (C), containing large blocks of blueschist (bs) greenstone and graywacke. The transitional relationship with the pebbly mudstone, and the lack of deformational fabric, suggest that the mud-matrix melange is a debris flow. A strain gradient on the left side of the large blueschist block (D) shows the transition from mud-matrix melange into sheared melange. View to SE.

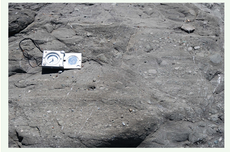


C. Mud-matrix melange containing irregular blocks of greenstone, graywacke, and a large blueschist block (bs). The transition into the pebbly mudstone at (A) and the lack of deformational fabric suggest a sedimentary origin.

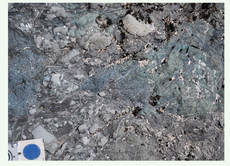


D. Transition from mud-matrix melange into sheared melange in a strain gradient along the margin of the blueschist block.

3 Melange of purely sedimentary origin

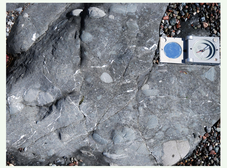


Bedded conglomerate. Clasts are rounded, mainly graywacke, and were partly lithified when they were incorporated in the conglomerate.



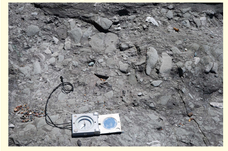
Structureless conglomerate, with two large blueschist boulders. Clasts of greenstone and graywacke are angular to sub-rounded.

Structureless conglomerate, with rounded blueschist boulder and pebbles of red and green chert.



Pebbly mudstone, with angular to subrounded clasts of graywacke.

4 Melange produced by soft-sediment disruption



Sandy block melange, produced by the disruption of unlithified massive greywacke sandstone. Clasts are irregular, may have diffuse boundaries, and in some cases fit adjacent clasts. Some more lithified clasts may be derived from interbedded conglomerate.

Broken formation / sandy block melange, produced by the disaggregation of unlithified interbedded sandstone and conglomerate. Note fragments of thinly-bedded fine-grained conglomerate at center.

Broken formation, produced by stretching and disaggregation of bedded sandstone.

Broken formation, produced by slump folding and disaggregation of bedded sandstone and shale. The fold lies discordantly on mud-matrix melange.

8 CONCLUSIONS

Transitions from conglomerate and pebbly mudstone of clearly sedimentary origin into stratally disrupted melange suggest that the melange formed primarily by sedimentary processes - probably down-slope sliding on the inner trench wall. Mixing of blueschist and other exotic clasts into the melange occurred at this stage. The distinctive structural style in much of the melange, with a scaly-clay fabric and shear bands, was imposed on the melange later, and is not primarily responsible for either the mixing of materials or the stratal disruption. The dominantly extensional nature of the deformation, and its superposition on earlier contractional structures, is consistent with extension in the accretionary wedge driven by underplating.

If the blueschist and other exotic clasts are detrital in origin, where did they come from? They are significantly older than the sediment in which they are now found (Ukar, 2012), and were likely derived from previously accreted and exhumed Franciscan terranes lying inboard of the trench. Exhumation of the blueschist is unrelated to the formation of the melange.

References

Cloos, M., 1982. GSA Bulletin, 93, 330-345.
Cowan, D.S., 1978., GSA Bulletin, 89, 1415-1423.
Ukar, E. 2012. Tectonophysics, 568-569, 154-169.

5 Deformational structures in melange

(Above) Normal fault placing structureless conglomerate against mud-matrix melange. View to NE.

(Left) folds in bedded chert. These folds may predate the incorporation of the chert into the melange.

Fault-propagation fold in graywacke sandstone and shale. The lower limb is cut out against the fault. This structure likely formed during subduction-related contraction.View to NE.

Broken-formation greywacke, folded (possibly during subduction-related contraction), and then cut by a SE-dipping normal fault. View to NE.

Contractional fold in thinly bedded graywacke cut by a SE-dipping normal fault. View to NE.

Melange fabric and discrete shears defining asymmetric clast geometry in a normal-sense (top NW) shear zone. View to NE.

Structure

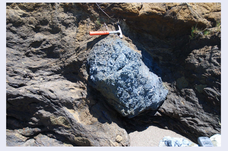
Four groups of structures can be recognized.
1) Soft-sediment structures, including loading, flame structures and sandstone dikes.
2) Stratal disruption of unlithified sediment, involving pinch-and-swell and pulling apart of beds and sedimentary clasts, disaggregation, small-scale normal faults within beds, and slump folds (panel 4).
3) Contractional structures, including reverse faults and fault-propagation folds (panel 5).
4) Pervasive deformation in consolidated or lithified state, to form a scaly-clay fabric and discrete shear bands. Clast are deformed to form asymmetric shapes. Shears may be conjugate, and are usually extensional (panel 6).
5) Late faults, predominantly normal and strike-slip, both sinistral and dextral.

Kinematic analysis of the deformation that formed the distinctive melange fabric was carried out by determining the intersection of the fabric with associated shear planes. The shear direction is normal to this intersection, and the sense of shear is the sense of the angle from the fabric to the shear plane. In some cases striations or fiber lineations could be measured. Data are shown in Panel 7 at bottom right.
Most shear planes are gently dipping with a normal sense of displacement, but the direction is highly variable: there are strong concentrations with NW, SW, and S senses of shear. This suggests roughly uniaxial vertical shortening as the main cause of the deformation in the melange. Steeper normal faults have mainly SW and SE senses of slip.

Steep dextral strike-slip faults trend close to N-S; sinistral faults are roughly E-W. These are likely related to post-Franciscan transform tectonics.

6 Sheared melange produced by deformation of mud-matrix melange

Mud-matrix melange with large blueschist and graywacke blocks, showing transition to sheared melange at right. Note rounded and undeformed clasts at left. View to N.



Blueschist clast in sheared melange. Clay matrix has a strong deformational fabric that wraps around the clast, and the asymmetry of the fabric pattern defines the sense of shear (top left, NW). View to NE

Graywacke block and disrupted chert lens in sheared melange. The disruption of the chert is mainly due to slip on top-left (top NW) shear planes. SW at top.

Greenschist blocks in sheared melange. The shape of the blocks is defined by conjugate shear planes; these, and the melange fabric, indicate approximately coaxial shortening normal to the fabric. SW at top.

Greenschist blocks in sheared melange. The greenstone is internally brecciated, but this is an inherited feature. The shape of the blocks is defined by the melange fabric and top-left (top NW) shear planes.

Sheared melange derived by deformation of broken formation graywacke. Deformation produced top-right shear planes and a fabric in the clay matrix. View to NE.

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