This article points out that the rocks in shear zones induced by 10^3 or 10^4 km displacement are a mixture of fragmented slabs embedded in a ductily deformed matrix. New principles are formulated as the guideline for studying such mélanges. [The SCI® indicates that this paper has been cited in over 130 publications.]

### Melanges and Non-Smithian Stratigraphy

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Scientific endeavors are personal. I worked for Shell Oil Company, lived in Texas, and married a Swiss. My late wife, Ruth, liked oceans and mountains. I maneuvered, therefore, to start a project on the Franciscan rocks of the California Coast Ranges in 1963.

The Franciscan used to be called basement; they are “hard” rocks that rarely have porosity to store hydrocarbons. Petroleum geologists do not study basement. After successes with my first two projects, however, my credibility with the management was such that I could persuade them of the relevance of Franciscan geology to oil exploration. The family moved to Morro Bay, California, and Ruth became a beachcomber for six months.

The discovery was made at one glance, but there was much afterthought.¹ The logic is clear: We have to have a non-Smithian stratigraphy. Conventional geological mapping and the stratigraphy of William Smith assume coherence of rock formations. Strata could be cut up and displaced along the faults, but those bounded by faults retain their coherence. The Franciscan rocks are, in contrast, incoherent, a mélangé as the French would say.

As I found out later, E. Greenly² discovered in 1919 that rock bodies in Anglesey are disintegrated by shearing, but neither he nor others appreciated the significance of that discovery: We have to change our outlook of the world. Geologists used to be “fixists,” believing that rocks on continents or ocean floors were always fixed where they are now found. My discovery removed this “fixistic” constraint: The Franciscan rocks have been pervasively sheared, and the total displacements along the innumerable shear planes of the mélangé add up to 10^4 or 10^5 km.

Nineteen sixty-three was the year of a great revolution in earth science when F.J. Vine and D.H. Matthews³ formulated the seafloor-spreading theory, leading to later developments of the plate-tectonic theory. They postulated displacement of the Pacific seafloor of 10^5 km during the last 10^8 years. I did not know then that I was gathering evidence to verify the corollary of the new paradigm: Wide expanses of the Pacific seafloor have been trenched under the Coast Range and fragments of ocean lithosphere have been left behind, embedded in pervasively sheared matrix to form the Franciscan mélangé.

My 1969 paper was to formulate a set of new principles, the principles of mélangés, and to propose this non-Smithian stratigraphy as a guideline for studies of mélanges that are found in mountain ranges all over the world. For this contribution to the “stratigraphy of mountains,” I was to receive the Wollaston Medal in 1984, the highest award of the Geological Society. Prior to that, however, I had to face establishment resistance against the new idea. The original manuscript was rejected by a referee, and it was accepted by the journal editor only after I agreed to a compromise to have it published in the “Geological Note” section for trivial communications. For more than a decade, I was pictured as a Don Quixote waging my lance against a windmill that was the US Geological Survey. The very non-acceptance, ironically, increased the number of citations: Young geologists adopting the non-Smithian stratigraphical principles to unravel the geologic history of mountains still have to cite the article, two decades after the discovery, because the word mélangé is found in few of the current textbooks.

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². Greenly E. The geology of Anglesey. London: His Majesty’s Stationery Office, 1919. 980 p. (Cited 113 times since 1945.)