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Deformation Lamellae Parallel to (10$\bar{1}$3) and (0001) in Quartz of the Coeur d'Alene District, Idaho

Abstract. *Deformation lamellae oriented parallel to the (10$\bar{1}$3) and (0001) crystallographic planes in quartz have been considered to be deformation structures unique to shock metamorphism induced by meteorite impact. Rocks of the Belt Supergroup of the Coeur d'Alene district, Idaho, contain quartz with deformation lamellae parallel to both (10$\bar{1}$3) and (0001). All available evidence indicates a geotectonic rather than an astrotectonic origin for the deformation lamellae of the district. Therefore, the uniqueness of these orientations to astrotectonic deformation is doubtful.*

Recently there has been considerable interest in establishing petrographic criteria for the recognition of structures formed by meteorite impact. Experimental deformation of rock specimens by hypervelocity shock waves has produced what are considered to be unique indicators of shock deformation (*1*). Among these unique indicators are multiple sets of planar lamellae in quartz, with preferred orientation parallel to (10$\bar{1}$3) and, less strongly, parallel to (0001) crystallographic planes. The uniqueness of these deformation structures is based largely on the failure to produce lamellae of these orientations in experimental deformation of quartz under low rates of strain and on the absence of reports of similar orientations from geotectonically deformed rocks (*2*).

Accepting the uniqueness of (0001) and (10$\bar{1}$3) lamellae, French (*1*) argues that their presence in quartz of the Onaping Formation at Sudbury, Ontario, is evidence that the Onaping was deposited immediately after a meteorite impact that formed the Sudbury basin.

I report here that orientation of deformation lamellae parallel to the (10$\bar{1}$3) and (0001) planes of quartz was found in rocks having no apparent meteorite impact history. Clearly, the scarcity of available reports on deformation lamellae makes arguments based on negative evidence rather tenuous. By this presentation I hope to encourage additional studies of geotectonic structures before the uniqueness of the criteria for recognition of astrotectonic structures is accepted.

The microfabric of the rocks of the Belt Supergroup in the Star Mine, Coeur d'Alene district, Idaho, was examined by me in 1964–65 to provide data for a study of deformation around mine openings (*3*). During the microfabric study, I became aware that, contrary to the report of Carter (*4*), deformation lamellae were occasionally oriented parallel to the basal plane (0001) of quartz. Deformation lamellae are predominantly parallel to (10$\bar{1}$3) of quartz in the samples from the Star Mine. At the time, the observation by itself did not appear to warrant reporting; but now the lack of available reports of such lamellae has led writers to conclude that these orientations are not to be found in geotectonically deformed rocks. The rocks of the Coeur d'Alene district have been complexly deformed and, despite the long history of mining in the area, no extensive microfabric-megafabric structural analyses have been made. However, in the available studies of the megastructure, the most recent of which is Hobbs *et al.* (*5*), no evidence is presented to suggest any extraterrestrial effect.

Samples from the Star Mine were collected from the walls of mine openings. Therefore, all samples had been affected by relatively low-velocity shock during blasting. Because of the limited nature of the study, the degree of deformation attributable to blasting was not determined directly. The statistical pattern of quartz lamellae paralleled the patterns of healed and unhealed microfractures in quartz and the major joint sets in the area. Therefore, it is thought probable that the lamellae are geotectonic rather than blasting features.

Of the samples examined, approximately 10 percent of the quartz grains studied contained deformation lamellae. Of 160 planes measured, five were parallel to (0001) and 48 were parallel to (10$\bar{1}$3). The accuracy of measurement is considered to have been ± 4°.

It is beyond the scope of this report to explain why basally oriented quartz lamellae are present in the rocks of the Coeur d'Alene district and apparently absent in other areas. One might observe that in sections containing basally oriented lamellae more orientation planes are represented, with a consequent reduction of the frequency of the (10$\bar{1}$3) plane. This suggests that under certain combinations of preferred quartz orientation and subsequently applied stress, easy directions and planes of translation in quartz are inopportunely oriented, and stress is accommodated on planes of greater resistance.

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Radiocarbon Content of Marine Shells from the Pacific Coasts of Central and South America

Abstract. *The radiocarbon content of contemporary pre-bomb marine shells from the region of upwelling of the Pacific coast of South America has been determined and found to be somewhat similar to the content of shells from the coast of California and the west coast of Mexico. Deviations of up to −8.5 percent with reference to the contemporary biospheric carbon-14 standard have been observed for the Peruvian coast. Values of from −0.35 to −4.04 percent have been obtained for marine shells from the Galápagos group. Problems associated with radiocarbon dates based on shells are discussed.*

In an earlier investigation the content of radiocarbon in contemporary pre-bomb marine shells from the region of upwelling of the California coast and the west coast of Mexico was determined in order to estimate the general magnitude of the upwelling effect as expressed by the apparent radiocarbon age (*1*). A knowledge of this fictitious age is also of considerable consequence in the application of radiocarbon dating to marine shells found in archeological sites, provided oceanic conditions since ancient times have not changed markedly.

This study has now been extended to the Pacific coasts of Central and

South America where a similar oceanic environment exists. During the spring and summer of the Northern Hemisphere, the courses of the California and the Humboldt or Peru currents are almost mirror images of each other along the west coast of the Americas. However, while the direction of prevailing winds off California changes in our summer, winds over the Peru Current remain the same (*2*). Average speed of the surface waters of the Peru Current near the coast is on the order of 25 cm/sec or slower (*3*), essentially of the same general magnitude as its counterpart in the Northern Hemisphere (*4*). In contrast, the water masses that are moved differ by almost a factor of 2—about 10^7 m^3/sec in the California Current and up to 2×10^7 m^3/sec in the Peru Current. Because such similarities and dissimilarities are found, it was thought desirable to determine if any differences could be recognized in the radiocarbon content of shells from the open coastal waters of the northern and southern beaches.

In equatorial latitudes a different condition prevails. The ocean currents mentioned above begin to flow away from the land while entering the regime of the complex system of equatorial currents. Thus the Latin American coast north of the equator is exposed to the waters of the equatorial countercurrent moving in a west-easterly direction from about April to January. As it approaches the continent, a division occurs that ultimately results in a reversal of the course of the water masses and two new entities, the North and South Equatorial currents (*5*). Without significant upwelling in this region, the apparent age of shell carbonates was expected to be of lesser magnitude. On the other hand, the subsurface equatorial undercurrent (or Cromwell Current), with a transport capacity of about 4×10^7 m^3/sec and a maximum velocity of 100 to 150 cm/sec at a depth of 100 m, might introduce appreciable quantities of radioactively older water along the coasts in question (*6*). This would then be reflected in a depressed radiocarbon content of marine shells growing in, and being in isotopic equilibrium with, these waters.

Another area investigated is the Galápagos Archipelago through which waters of the South Equatorial and Peru currents flow westward at about 25 m/sec or slower. Under the ocean surface the Cromwell Current extends

Table 1. Carbon-14 content of marine shells from the west coasts of Central and South America.

UCLA Lab No.	Location and collection date	Shell species	Uncorrected δC^{14} (‰)*	C^{13}/C^{12} (‰)	Corrected ΔC^{14} (‰)†
1249A	Guayaquil, Ecuador (1927)	*Cerithidea valida* (Adams)	+1.01 ± .45	−5.72	+2.18
1249B	Guayaquil, Ecuador (1927)	*Thais biserialis* (Blainville)	−1.15 ± .53	+1.84	−1.51
1254	Port Parker, Costa Rica (1935)	*Strombus granulatus* (Swainson)	−3.11 ± .43	+1.74	−3.45
1255A	Santiago Is., Galápagos Is. (1934)	*Kelletia kelleti* (Forbes)	−1.48 ± .62	+0.35	−1.55
1255B	Santiago Is., Galápagos Is. (1934)	*Astraea* (*Uvanilla*) *undosa* (Wood)	−3.68 ± .94	+1.88	−4.04
1255C	Espanola Is., Galápagos Is. (1934)	*Fasciolaria* (*Pleuroploca*) *princeps* (Sowerby)	−0.42 ± .51	+1.33	−0.68
1255D	Santa Cruz Is., Galápagos Is. (1932)	*Nerita* (*Ritena*) *scabricosta* (Lamarck)	+ .22 ± .48	+2.88	− .35
1256A	Secas Is., Panama (1935)	*Vasum caestus* (Broderip)	+ .42 ± .61	+1.48	+0.12
1256B	Secas Is., Panama (1935)	*Strombus galeatus* (Swainson)	− .90 ± .58	+1.30	−1.16
1277	Antofagasta, Chile (1925)	*Concholepas concholepas* (Bruguière)	−2.61 ± .40	+0.09	−2.63
1278	Valparaiso, Chile (1930–1940)	*Tequla aler* (Lesson)	−4.09 ± .87	+1.32	−4.34
1279	Peru (1930–1940)	*Oliva peruviana* (Lamarck)	−8.29 ± .48	+1.15	−8.50
1282	Northern Peru (1930–1940)	*Strombus peruvianus* (Swainson)	−3.56 ± .57	−0.22	−3.52

* Expressed with respect to 0.95 NBS oxalic acid standard. † Correction used is $\Delta C^{14} = \{[(1 + \delta C^{14})/(1 + 2\delta C^{13})] - 1\} \times 100$, suitable for intercomparison of shells. The values obtained are not normalized for the fractionation expected between shell and wood or similar terrestrial organic matter.

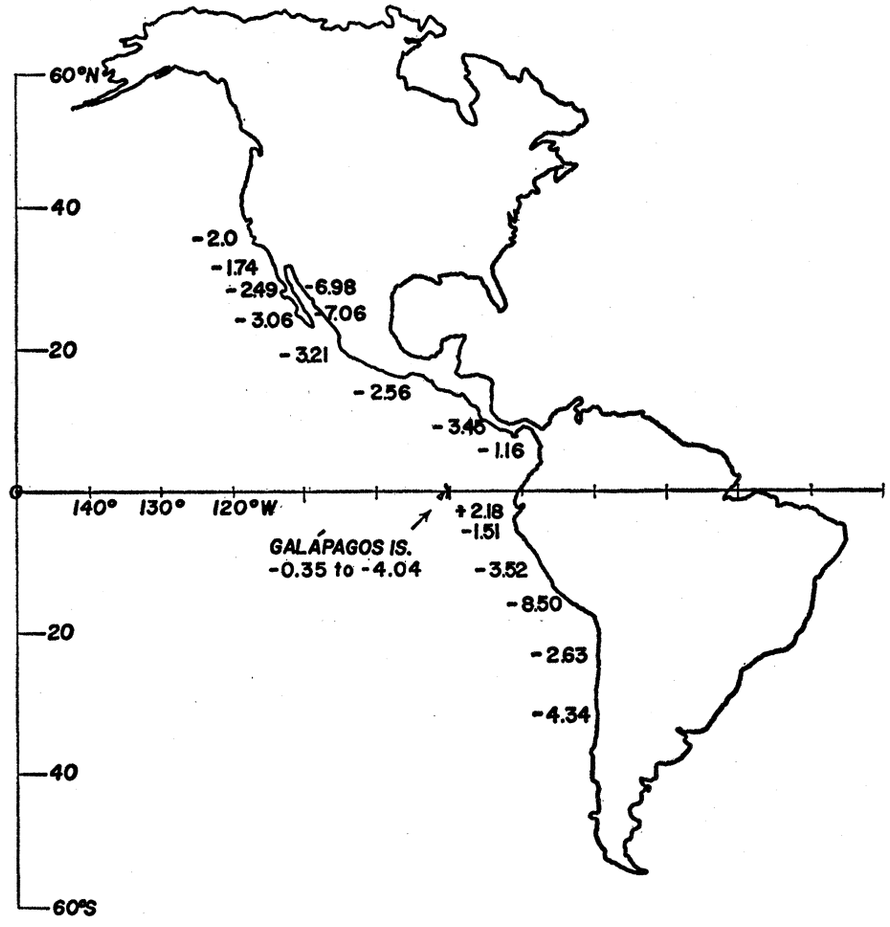

Fig. 1. Collection sites of shells used in this study. Data from California and western Mexico are from previous analyses (*1*).

from the west (142°E) almost to the Galápagos (92°E), where, in the vicinity of Albemarle Island, its speed diminishes and the core deepens. Toward the east of the archipelago this undercurrent is not very significant, and the further distribution of the large volume of water is unknown (see *7*).

The results of our study are given in Table 1 and a geographic comparison by map in Fig. 1 (*8*). Apparently, conditions on the coasts of Chile and Peru correspond to conditions along the Mexican coast where an effect of -240 ± 80 years or -3.0 ± 1 percent relative to 0.95 the count rate of the National Bureau of Standards oxalic acid for radiocarbon laboratories (contemporary biospheric standard) is observed. The shell sample from Costa Rica (UCLA-1254) fits into an extension of the prevailing values along the Mexican coast. However, in equatorial latitudes of Panama and Ecuador a deviation of only about -100 ± 80 years or -1.2 ± 1 percent seems to apply. It is interesting to note how the trend in the radiocarbon content of the shells follows the large-scale pattern of ocean currents.

Conditions similar to that encountered in and near the Gulf of California, with a maximum of −7.06 percent, can occur on the Peruvian coast where a −8.5-percent value was obtained. Such high fluctuations stress the need for careful study of the marine environment from which shells in archeological sites may have originated (*1*).

Although there is limited knowledge of the archeology of the Galápagos Archipelago, so far no evidence of a permanent prehistoric population of man has been found, and there is serious doubt that there ever will be because of the notorious lack of a supply of fresh water. Occasional visits from the South American mainland by balsa rafts, however, appear to have occurred long before the discovery of the islands by de Berlanga, Bishop of Panama, in A.D. 1535 (*9, 10*). For marine shells from Galápagos, a difference from biospheric land carbon of −0.35 to −4.04 percent appears to be typical, and this should be taken into account when anthropological or geomorphological samples are dated. In other words, deviations as high as about 300 years or so may be encountered. Consequently, it would be necessary to restrict carbon-14 sampling to stratigraphic increments whose true ages differ by more than 300 years. Similar considerations apply to other mainland beaches where ranges in the specific activity of shells are encountered (*11*).

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Landslide Noise

Abstract. *Acoustical monitoring of real landslides has revealed the existence of subaudible noise activity prior to failure and has enabled prediction of the depth of the seat of sliding when conducted in boreholes beneath the surface. Recordings of noise generated in small slopes of moist sand, tilted to failure in laboratory tests, have been analyzed to determine the foci of discrete subaudible noise events. The noises emitted shortly before failure were plotted close to the true sliding surface observed after failure. The foci of earlier events lay either within the central portion of the sliding mass or in a region behind the failure surface. The head and toe zones were devoid of strong seismic activity.*

The transient, audiofrequency, sonic oscillations that emanate from such varied materials as metals, ice, rocks, and soils when they are strained elastically have been referred to as microseismic, seismoacoustic, elastic-impulse, or subaudible noise activity. While considerable research, begun by Obert (*1*), has been devoted to the subaudible noises associated with mining and other underground works, there has been little application of this technique until recently to surface phenomena such as landslides. Since both American (*2*) and Russian (*3*) scientists have achieved reasonable success with the subaudible technique for forewarning of failures or rock bursts underground, the possibility of predicting landslides and slope failures was investigated. In addition Japanese (*4*) and Americans (*5*) have been studying the method as a possible means of predicting earthquakes.

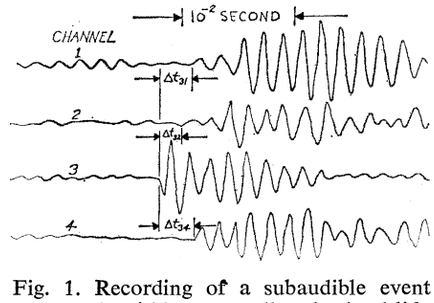

Fig. 1. Recording of a subaudible event generated within a small-scale landslide and received by four piezoelectric transducers, showing the three time delays. The ring-down is the natural frequency of the cantilever-mounted transducer (580 cycle/sec), and not a characteristic of the subaudible noise.

Fieldwork on existing landslides revealed the presence of subaudible noises and noted a rough correlation between the noise rate and the stability of the slope once the local background rate was known (*6*). The depth to the seat of sliding has been successfully identified from relative noise rates in a borehole in a landslide. However, attempts to locate the source of the noises with arrays of noise detectors on the surface, were frustrated by high levels of background noise, poor coupling between geophores and the landslide mass, the rapid attenuation of the seismic energy—especially the higher-frequency portion—and finally the extreme heterogeneity of most landslides studied (*7*). In an effort to determine the precise origin of the noises and so direct future field activities,