

the number of chronologic regions merely increases the size of the error bars.

Hart and Press (11) have proposed that in the Atlantic the velocity of  $S_n$ , the  $S$ -wave in the lid, varies with age, being 4.58 km/sec in the regions younger than 50 million years and 4.7 km/sec in the regions older than 50 million years. At the epicentral distances used by Hart and Press,  $S_n$  travels at the highest  $S$ -wave velocity within the lid. If the  $S$ -wave velocity increases with depth in the lid, the body wave observations can be explained while preserving the notion of a constant  $S$ -wave velocity at the same depth throughout the basin. In our third experiment we allowed the lid density,  $V_p$ , and  $V_s$  to be linear functions of depth in the lid; the same set of relations was used for the entire Pacific. The increase of properties with depth was abruptly truncated by the start of the channel. The properties of the channel and subchannel were as before. The gradient of  $V_s$  in the lid was adjusted to match the values quoted by Hart and Press for the bottom of the lid at 25 and 75 million years. The results of the least-squares inversion gave only small changes from the result of Fig. 1. In the youngest region, the lid is so thin that a new lid velocity does not affect the thickness. At 50 million years (region 5), the average lid velocity is 4.6 km/sec, as in the preceding calculation, and the thickness is the same as in Fig. 1. In any case, the new least-squares fit lies well within the error bars of Fig. 1.

In the fourth calculation, we tested the assumptions regarding the channel-subchannel interface. We continued to assume that the depth to this interface is a constant throughout the Pacific; to make this depth a separate variable in each of the four regions leads to unstable solutions. The other parameters were fixed as before. A least-squares fit to the five-parameter system (four lid thicknesses and the depth to the subchannel) gave a depth to the subchannel of 175 km, virtually identical with the constrained estimate of the second calculation (180 km).

In the fifth inversion experiment we raised  $V_s$  in the subchannel to 4.75 km/sec, with the other parameters fixed as in the fourth calculation. The resulting five-parameter fit gave a depth to the subchannel of 207 km, an increase from 180 km. The new lid thicknesses are all within 6 km of the previous values. Thus, an increase in the subchannel velocity can be balanced by a

thicker channel and a thinner subchannel without significant change in lid thicknesses.

Raitt (12) has stated that anisotropy may be present in the upper mantle of the central Pacific. There is also information bearing on this point from surface waves crossing the Nazca plate in a relatively dense pattern of paths (5). Unfortunately, with the present data we cannot distinguish between anisotropy and a more detailed regional variation in structure. The introduction of anisotropy (or additional isotropic layers) as an additional model parameter could not worsen the fit, but would lead to increased instability in the solution.

Inversions of these surface wave observations are incapable of giving simultaneous determinations of lid and channel velocity and thickness, plus anisotropy, as a function of age. However, any reasonable assumption leads to the result that the lid is very thin or absent near the ridge crest. The lid must thicken with age, reaching a thickness of about 60 km after 50 million years and about 85 km after 100 million years. After this age the lid continues to grow, although the thickness we get depends sensitively on the assumptions we make.

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## Asymmetric Adsorption of Alanine by Quartz

**Abstract.** Radioactive D- and L-alanine hydrochloride in  $10^{-5}$  molar dimethylformamide solution was adsorbed by D- and L-quartz to the extent of 20 to 30 percent, as shown by radioactivity loss. D-Quartz preferentially adsorbs D-alanine and L-quartz adsorbs L-alanine. The extent of asymmetric preferential adsorption is about 1.0 to 1.8 percent, at the 99.9 percent confidence level.

Since the reports (1) that D- and L-quartz are capable of adsorbing optical enantiomers to different extents have recently been called into question (2), we have undertaken to investigate the possible "asymmetric adsorption" of amino acids by D- and L-quartz; we have used a novel technique that does not depend (as have earlier studies) on the polarimetric measurement of optical activity (3). We measured the radioactivity of very dilute (about  $10^{-5}M$ ) solutions of  $^{14}C$ - and  $^3H$ -labeled D- and L-alanine in anhydrous dimethylformamide (DMF) before and after equilibration with dried,

powdered D- and L-quartz samples. The difference in radioactivity count before and after exposure to the quartz then provided a direct measure of the fraction of the total alanine adsorbed, and the variation in the fraction adsorbed for the D- versus the L-alanine likewise afforded an indication of any asymmetric bias in the adsorption process. Two typical experiments with both D- and L-quartz (4), with results shown in Table 1, were conducted as follows. A dried sample of radioactive alanine hydrochloride was dissolved in sufficient anhydrous DMF (dried by molecular sieve; water content about 26 parts per

Table 1. Adsorption of <sup>3</sup>H-labeled L-alanine by *d*- and *l*-quartz.

| Item                      | Radioactivity (counts per 5 minutes $\pm$ S.D.) |                    |
|---------------------------|-------------------------------------------------|--------------------|
|                           | <i>l</i> -Quartz                                | <i>d</i> -Quartz   |
| Control                   | 221,853 $\pm$ 903                               | 221,853 $\pm$ 903  |
| Supernatant               | 158,957 $\pm$ 1,571                             | 162,844 $\pm$ 763  |
| Loss                      | 62,896 $\pm$ 1,812                              | 59,009 $\pm$ 1,182 |
| Loss difference           |                                                 | 3,887 $\pm$ 1,746  |
| Adsorbed (%) <sup>*</sup> | 28.35 $\pm$ 0.82                                | 26.60 $\pm$ 0.53   |
| DA (%) <sup>†</sup>       |                                                 | 1.75 $\pm$ 0.78    |

<sup>\*</sup> Ratio of 100 times the count loss to the control count. <sup>†</sup> Differential of adsorption (DA) is the ratio of 100 times the count loss difference to the control count, or the percentage adsorption by *l*-quartz minus the percentage adsorption by *d*-quartz.

million) to make a  $2 \times 10^{-5}M$  solution (stored under septum). A 9.5-ml portion was removed with a hypodermic syringe and introduced onto 7.5 g of dried (170°C, 3 hours, about 0.1 torr) quartz powder (120 to 250 mesh; the surface was calculated to be about 250 cm<sup>2</sup>/g) contained in a septum-stoppered flask with an outlet for a vacuum line. The mixture was stirred magnetically for 1 hour and allowed to settle for 3 hours. Triplicate portions of the supernatant were removed in sequence and placed in a liquid scintillation counter; each was counted in triplicate, and the resulting nine separate countings were averaged. Nine similar countings on three portions of the original untreated DMF solution were conducted consecutively as the control. Table 2 indicates the approximate reproducibility of a series of such experiments with both D- and L-alanine. No adsorption of radioactive alanine was observed when the solvent was water or aqueous alcohol. The DMF was scrupulously dried, and the experiments were performed in a closed system since greater amounts of water in the DMF were adsorbed in preference to or in competition with the alanine, leading to random, nonreproducible adsorption values. The quartz powder was completely freed of physically ad-

sorbed water by the technique employed, as indicated by control experiments with radioactive <sup>3</sup>H<sub>2</sub>O.

Table 2 shows that the total adsorption of alanine by quartz from  $2 \times 10^{-5}M$  anhydrous DMF solution amounts to some 20 to 30 percent under the conditions employed, corresponding to a gross adsorption of about 0.5 to 0.7  $\mu$ g of alanine per gram of quartz. Furthermore, *l*-quartz adsorbs L-alanine preferentially and *d*-quartz adsorbs D-alanine, the "differential adsorption" varying between 1.0 and 1.8 percent. Standard statistical evaluation (*t*-test) of the data on which Table 2 is based suggests that the differential adsorption figures shown are valid at the 99.9 percent confidence level.

In view of the negative results obtained by Amariglio *et al.* (2) and their critique of the earlier literature, we believe that the above experiments

performed under aprotic, anhydrous conditions may constitute the first valid demonstration of the ability of quartz to bind optically active substrates with an asymmetric bias. However, since our present observed differential adsorption is small in comparison with the total adsorption, we feel obliged to confirm our observations, using D,L-amino acids and column chromatography, along with gas chromatographic evaluation (5) of the enantiomeric composition of our eluates. The implications of such observations for the abiotic origin of optically active organic molecules in nature have been reviewed (1).

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## Development of the Circum-Antarctic Current

**Abstract.** Deep-sea drilling in the Southern Ocean south of Australia and New Zealand shows that the Circum-Antarctic Current developed about 30 million years ago in the middle to late Oligocene when final separation occurred between Antarctica and the continental South Tasman Rise. Australia had commenced drifting northward from Antarctica 20 million years before this.

One of the main objectives of Leg 29 of the Deep-Sea Drilling Project was to determine the evolution of the Circum-Antarctic Current south of Australia and New Zealand and to decipher its effects on Cenozoic deep-sea sedimentation in the Southern and South Pacific oceans. Several sites were drilled to evaluate the development of this major current system (1).

The Circum-Antarctic Current is of great oceanographic and climatic importance because it transports more than  $200 \times 10^6$  m<sup>3</sup> of water per second, probably the largest volume transport of any ocean current (2, 3). It also

circulates completely around Antarctica, mixing waters of all oceans. The combined effects of plate tectonic movements at high southern latitudes and Antarctic glacial development during the last 60 million years have led to the formation of the present Circum-Antarctic Current. Initial development of the Circum-Antarctic Current resulted from the opening of the final constricting region south of Australia. Earlier separations had already occurred south of New Zealand and in the Drake Passage south of South America (4). Magnetic anomalies adjacent to New Zealand record the separation of New Zealand

Table 2. Replicate adsorptions of alanine by *d*- and *l*-quartz.

| Form | Percentage ( $\pm$ S.D.) adsorption by: |                  | DA (%) <sup>*</sup> |
|------|-----------------------------------------|------------------|---------------------|
|      | <i>l</i> -Quartz                        | <i>d</i> -Quartz |                     |
| L    | 29.35 $\pm$ .43                         | 28.33 $\pm$ .47  | 1.02 $\pm$ .29      |
| L    | 28.35 $\pm$ .82                         | 26.60 $\pm$ .53  | 1.75 $\pm$ .78      |
| L    | 22.21 $\pm$ .42                         | 21.03 $\pm$ .45  | 1.18 $\pm$ .53      |
| D    | 29.08 $\pm$ .59                         | 30.38 $\pm$ .81  | -1.30 $\pm$ .65     |
| D    | 25.92 $\pm$ .63                         | 26.88 $\pm$ .66  | -0.96 $\pm$ .44     |

<sup>\*</sup> The differential adsorption (DA) is the percentage adsorption of *l*-quartz minus the percentage adsorption by *d*-quartz. The use of  $\pm$  indicates standard deviation.