with ten sample volumes of $6N$ HCl at room temperature or with a 3-hour benzene-methanol (1 : 1) reflux. These results indicate that the inositols are bound in the sediment, and that they are not associated with lipid-extractable material, for example, phosphatidyl inositol. Treatment of sediment sample 4 with $6N$ HCl at 100°C for only 60 minutes (instead of 48 hours) released approximately 90 percent of the bound *myo*-inositol as free inositol. Large amounts of free sugars were also released, which interfered with the detection of the other inositol isomers. Extraction of samples 1, 2, and 4 with $1M$ NaOH (60°C, 4 hours) followed by a 48-hour HCl hydrolysis of this extract released > 95 percent of the inositols. On acidification of the NaOH extract, the humic acids precipitated and about half of the inositol was found in the humic acid precipitate after acid hydrolysis.

The supernatant from the humic acid precipitate of samples 1 and 2 was treated with sodium hypobromite, which oxidizes the free inositols and fulvic acids but not the inositol hexaphosphates (*5*, *15*). The inositol hexaphosphates were precipitated with ferric ion and then acid hydrolyzed and were found to contain about 5 percent of the total inositol in sediment samples 1 and 2. The ratio of inositol isomers in the hexaphosphate fraction was the same as in the whole sediment sample.

Because this inositol analysis is relatively simple and sensitive, the method may serve as a base line with which to compare other organic compounds in sediments instead of using total organic carbon as a base line. The steady decrease in the inositol concentration with age in the sediment samples examined could be due to bacterial attack, leaching of the sediments, or instability of the inositols. Since inositol is so stable to acid hydrolysis, the loss is probably due to the action of bacteria and leaching. The possible slow interconversion of inositol isomers that remain in the sediments could be the basis of a dating procedure.

The inositols in soils are probably bacterial in origin (*16*). We examined three different marine sediment bacteria from the Del Mar Lagoon and found the same relative proportion of inositol isomers in the bacteria as in the sediments. Other contributing sources of marine inositols would be oceanic detritus and terrestrial sources.

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11. Core samples (from which sediment samples were taken) were immediately frozen to −20°C and kept at this temperature up to the time of analysis. To reduce possible contamination, only material from the inside of the core samples was used. Dry weights were determined by drying samples at 110°C to constant weight.
12. In the GC-MS analysis we used a LKB-9000 fitted with a glass column (1.8 m long by 0.32 cm in inside diameter) containing 3 percent OV-17 on Gas-Chrom Q. The column was programmed from 150° to 300° at 10°C per minute. Helium was used as the carrier gas at a flow rate of 26.4 ml per minute. All spectra were recorded at 70 ev. Under these conditions the inositol isomers had the following retention times (in minutes): *neo*-, 5.0; D-*chiro*-, 5.9; *scyllo*-, 7.0; and *myo*-, 7.5.
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22. We thank Andrew Soutar for supplying the samples from the Santa Barbara Basin and Jeffrey L. Bada for sample SOT W7 P12. The samples from the various Deep Sea Drilling Project sites were supplied (to J. L. Bada) through the assistance of the National Science Foundation. Samples of known inositol isomers were supplied by William R. Sherman. Bacteria cultures isolated from sediment samples were supplied by Kenneth H. Nelson. This work was supported by NSF grant MPS 72-05043. The gas chromatography–mass spectrometry was obtained in part with NSF grant GP 18245.

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Yearly Seismic Energy Release: World Totals Versus Ridge System Totals

Abstract. *Yearly seismic energy totals for many different regions of the earth show highs in 1965 and lows in 1967. Correlations found between totals for ridge systems and for the world are attributed to ambient stresses, which are close to those needed for failure in the lithosphere underlying those ridge systems. Energy highs for many different plate edges are thought to be the result of triggering by the large Alaskan earthquake of 1964. Other suggestions of triggering by major earthquakes are found in 1969 and 1971.*

Evidence has recently been presented which suggests that similarities in the seismic activity of widely differing tectonic environments may be related to worldwide fluctuating stress fields (*1*). This evidence is in the form of time series of counts per unit time of earthquakes with magnitudes greater than a chosen threshold. Many of the time series from widely separated regions were found to have activity highs in 1965 and lows in 1966 and 1967. Similar observations have previously been made using yearly seismic energy totals for differing tectonic regions (*2*, *3*), as well as cumulative strain release totals (*4*). In one of these investigations (*3*), yearly totals for ten of 15 regions studied were found to have high values in 1965, while totals for eight regions were found to have low values in 1967. Regions having highs in 1965 or lows in 1967, or both, included oceanic ridge systems contributing as little as 0.5 percent to the yearly seismic energy totals for the world, as well as major earthquake zones. It was concluded that such relations, displayed over relatively short time intervals (1 year), required the existence of an efficient worldwide mechanism of energy distribution, which produced both major earthquakes throughout the world and minor activity along individual rising plate edges. In this report additional information is provided concerning these suggested relations, and the possible significance of this information is discussed in view of the hypothesis proposed by Chinnery and Landers [worldwide fluctuating stress fields (*1*)] and the hypothesis proposed by Anderson [accelerated plate tectonics (*5*, *6*)].

Yearly seismic energy totals for most of the seismically active regions of the earth are shown in Fig. 1. National Earthquake Information Service (NEIS) listings of earthquakes in a punched-card format were used in these computations. Data prior to 1964 were not considered because of incompleteness. Energies (E) were computed according to the formulation given in Richter [$\log E = 5.8 + 2.4m_b$ (7)] from NEIS body wave magnitudes (m_b). In the event that such magnitudes were not assigned, available NEIS surface wave magnitudes were taken and converted to body wave values. For several large earthquakes it was necessary to obtain magnitude data from other sources because no values were punched on the NEIS card. Since the necessity for these corrections was not known before our earlier publications (2, 3), some of the totals shown in this report differ from totals published earlier. Similarities in the yearly seismic energy totals are apparent for many of the regions shown in Fig. 1. Eleven of the 17 regions have high totals (highest or second highest) in 1965, while eight of the regions have low totals (lowest or second lowest) in 1967. The probability of such an occurrence in entirely random data is approximately 10^{-5}. Especially conspicuous is the similarity in the totals for the differing ridge systems (Fig. 1, a through e). For the five ridge systems, four have either their highest or second highest totals in 1965 and three have their lowest totals in 1967. Most of these ridge systems have yearly totals on the order of 10^{20} ergs. The region in Fig. 1f, which to some extent also represents a ridge system, has its second highest total in 1965 and its second lowest total in 1967. Yearly totals for this region are on the order of 10^{21} ergs. In Fig. 2, the summed totals for regions that are predominantly ridge systems (Fig. 1, a through e) are compared to world totals. Although the yearly totals for the summed plot for ridge systems are only on the order of 10^{21} ergs, correlations with yearly world totals, which are on the order of 2×10^{23} ergs, are remarkable. Like the world totals, ridge system totals (which generally represent only 0.5 percent of the world totals) are highest in 1964 and lowest in 1967. Correlations in other years are also very good.

Three possible inferences that may be drawn from these correlations are: (i) worldwide fluctuations in stress fields produce, or trigger, major earthquakes throughout the world as well as smaller earthquakes along individual rising plate edges; (ii) major earthquakes trigger other earthquakes throughout the world, especially along rising plate edges; and (iii) minor earthquakes along rising plate edges trigger major earthquakes throughout the world. If the first inference is correct, major earthquakes should sometimes precede and sometimes follow periods of high activity on rising edges. The second inference implies that periods of high activity on rising plate edges would follow major earthquakes, while the third inference implies that major earthquakes would follow periods of high activity on rising plate edges.

The fact that 11 of the 17 regions studied have their highest or second highest totals in the year following the large Alaskan earthquake of 28 March 1964 (energy on the order of 10^{26} ergs) suggests that the second inference is best supported by the data. Highest totals observed in 1964 for Africa (Fig. 1e) and for Southeast Asia (Fig. 1m) are also the result of earthquakes which followed the Alaskan event. We should note, however, that this observation, by itself, is not significant because of the relatively early date of the Alaskan earthquake. In all, a total of 12 of 16 regions (excluding the Alaska and Aleutians region) have earthquakes which could be considered as being triggered by the Alaskan event. In each of these 12 regions, the triggered earthquakes are of sufficient magnitude to produce either the largest or second largest yearly energy totals in 1964 or 1965.

The second highest energy total for the world occurred in 1971. The largest earthquake in the world for that year and the earthquake responsible for approximately half of the 1971 total occurred in the Melanesia region (Fig. 1k) on 10 January and had a body wave magnitude of 7.3. High totals are also found in 1971 for the southern East Pacific Rise and Chile Rise (Fig. 1a) and for the southern Mid-Atlantic Ridge (Fig. 1c). Because of the early date of the Melanesian earthquake, high totals for ridge systems in 1970 and 1971 might be expected if the first inference is correct, in 1971 or later if the second inference is correct, and in 1970 if the third inference is correct. Since the ridge totals indicate a distinct high in 1971 and since earthquakes primarily responsible for the high values on ridge systems in 1971 were found to have occurred after 10 January, we must conclude that the second inference is best

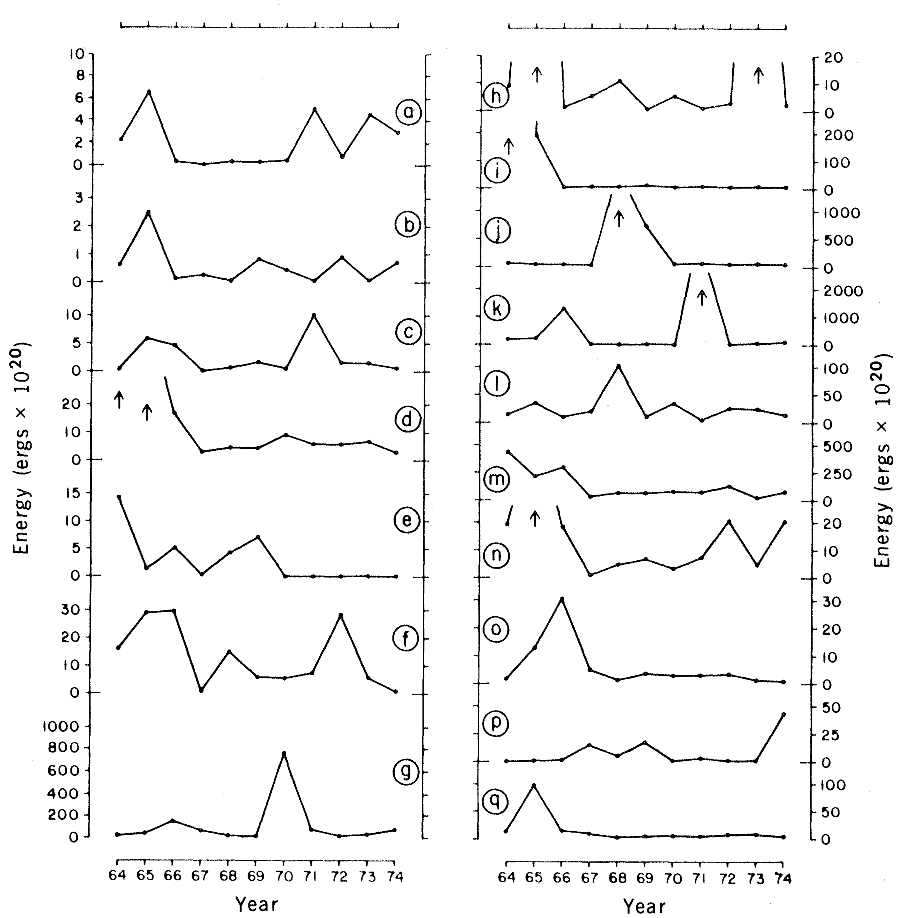

Fig. 1. Yearly seismic energy totals for most of the seismically active regions of the earth. The regions are (a) southern East Pacific Rise and Chile Rise; (b) northern Mid-Atlantic Ridge; (c) southern Mid-Atlantic Ridge; (d) Indian and Antarctic ridge systems; (e) Africa; (f) northern East Pacific Rise and west coast of North America; (g) South America; (h) Central America; (i) Alaska and the Aleutians; (j) Kamchatka, Kuril, Japan, and the Mariana Islands; (k) Melanesia; (l) Tonga and the Fiji and Kermadec islands; (m) Southeast Asia; (n) Asia; (o) Europe; (p) West Indies; and (q) South Sandwich Islands. Arrows indicate energy totals which are off the plots. Coordinates of grids used to approximate these regions are available from the author.

supported by the data. Other possible responses to the 10 January earthquake may be found in 1972 for Fig. 1, b, f, and n.

The third highest energy total for the world occurred in 1969. The largest earthquake in the world for that year and the earthquake responsible for most of the 1969 total occurred off the western coast of Spain on 28 February and had a body wave magnitude of 7.3 (the unusual epicenter of this earthquake is not located within any of the 17 regions investigated). High totals are also found in 1969 for the northern Mid-Atlantic Ridge (Fig. 1b), Africa (Fig. 1e), and the West Indies (Fig. 1p). Since the largest earthquakes in 1969 for all of these regions occurred after 28 February, and since totals for ridge systems are generally higher in 1969 than in 1968, we must again conclude that the second inference is best supported by the data. We note that the most obvious responses occur on ridge systems in close proximity to the magnitude 7.3 earthquake (the northern Mid-Atlantic Ridge and Africa). The other suggested response (the West Indies) also occurs in a region close to this epicenter.

The times of occurrence and epicentral locations of the triggering earthquakes and the triggered earthquakes mentioned in this report imply stress propagation rates on the order of 10^3 to 10^4 km/year. Although no specific rate appears with conspicuous frequency for the events investigated here, there is evidence for global triggering at specific rates in the range 10^3 to 10^4 km/year (*8*).

Chinnery and Landers (*1*) have proposed the existence of worldwide fluctuating stress fields which normally trigger earthquakes only in areas where the ambient stress is very close to that needed for failure. They also suggested that the stresses may occasionally be quite large, resulting in widespread triggering of large events. Anderson (*5, 6*) has proposed that after great decoupling earthquakes, plate motions might be expected to accelerate and trigger earthquakes in adjacent portions of the arc at rates on the order of 10^2 km/year. These hypotheses have been mentioned as possible explanations for unusual periods of global seismic activity. Combining these hypotheses with the limited observations presented here results in an interpretation which could be considered as a refinement of an earlier interpretation (*2, 3*) and as an extension of the proposals of Chinnery and Landers and of Anderson. In this proposed interpretation, major earthquakes are viewed as an immediate cause of fluctuating stress fields which propagate at rates as high as 10^4 km/year, triggering earthquakes on ridge systems where ambient stresses are close to failure.

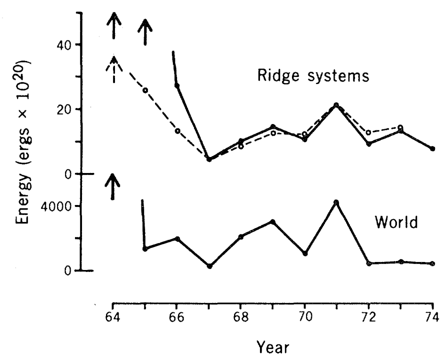

Fig. 2. Yearly seismic energy totals for ridge systems (Fig. 1, a through e) and for the world. The dashed line superimposed on the ridge system totals represents yearly energy totals for the world based on International Seismological Centre data. Arrows indicate energy totals which are off the plots. For more details see (*9*).

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10. Contribution No. 778, Hawaii Institute of Geophysics. This research was supported by NSF grants GA 37118X1 and DES 75-14814. I wish to thank the World-Wide Standardized Seismographic Network for providing the data base essential to this investigation. Appreciation is also expressed to George Sutton, Eduard Berg, Frederick Duennebier, Harold Loomis, and Gaylord Miller for their helpful comments. Drafting and computer programming were provided by Charles McCreery. The editorial assistance of Ethel McAfee is also acknowledged.

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Interrelations Among Isotopically Anomalous Mercury Fractions from Meteorites and Possible Cosmological Inferences

Abstract. *The magnitudes of the mercury anomaly found in unequilibrated meteorites appear to fit a trend. The excesses in the ratios of mercury-202 to mercury-196 are related by simple multiplication factors. This periodicity may be interpreted in terms of the mode of production and ejection of the anomalous isotope from a stellar source.*

Isotopically anomalous $^{202}Hg/^{196}Hg$ ratios in a number of unequilibrated chondrites have been reported (*1, 2*). These isotopes were the only ones measured by the neutron activation technique used. The Hg was extracted from irradiated samples of stepwise heating. The isotopically anomalous fractions represent only a very few of the total number of fractions collected in repeated experiments on any particular meteorite. Thus most aliquants contain only material with "normal" Hg—that is, Hg with terrestrial isotopic ratios—or have undergone mixing such that any anomalous Hg is masked because of its low relative concentration. Since experimental procedures could not account for the isotopic variations, it was necessary to suggest a nucleogenetic origin (*1*).

In this report we examine the anomalous fractions themselves in terms of their interrelations, their relation to other fractions released during heating, and some possible implications of these relations. We attempt to recognize trends that will suggest the conditions under which the anomalous isotope was formed and how it became incorporated into material sampled by the solar nebula. The results have cosmological implications, which are discussed.

When the data are examined, it is noted that a number of anomalous Hg isotopic ratios appear to recur. The number of cases with a particular anomalous ratio decreases with increasing magnitude of the anomaly. The ratios are arranged in groups in Table 1 to reflect this tendency. The standard deviations in the means of the groups containing the most entries (groups 1 and 2, containing seven