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太平洋西部中国沿岸海平面的变化*

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在有关世界大陆架地形和沉积的许多著作中，已对更新世冰期的低海平面作过研究。目前的残留海岸沉积和化石深度表明，冰川消溶前的海平面可能比现代低150米。海平面上升的大约深度和年代，是根据对残留的或准化石的海岸贝壳，和对从大陆架挖取或钻

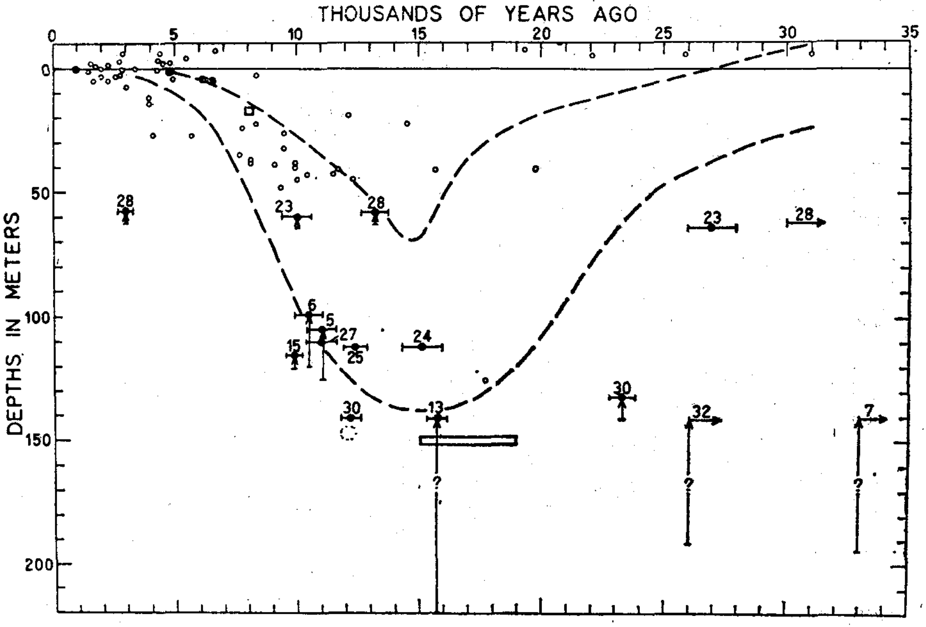

Fig. 1

图1 Milliman 和 Emery (1968)制订的全新世世界大洋（主要是大西洋）海平面数据包络曲线图。叠置其上的数据，系取自亚洲东部：左上角的实心点是朝鲜的，空心点——日本，有数字标明的点——黄海海底(Emery 等，1971)，而两个矩形是最近中国科学家在渤海湾(150米)和福建近海(17米)进行岩芯取样所测得的。

Fig. 1. Envelope for Holocene sea-level data for general world ocean (mostly Atlantic) from Milliman and Emery (1968). Superimposed are data from eastern Asia: solid dotes at upper left——Korea, open circles——Japan, numbered points——floor of Huanghai Sea (Emery et al., 1971) and two rectangles-recent measurements by Chinese scientists for samples from borings in the Bohai Bay (150m) and off Fukien (17m).

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* 伍兹霍尔海洋研究所研究论文第4790号。
中国科学院海洋研究所调查研究报告第625号。
这里，谨向中国科学院和美国科学院通过其学者交流委员会在1979年10月为 Emery 安排了中华人民共和国之行表示感谢。在这次旅行中，Emery 就海平面变化这一课题与很多科学家进行了讨论，本文的另一作者尤芳湖就是其中之一。伍兹霍尔海洋研究所的海洋工业计划帮助完成了这项研究。

取的泥炭沉积进行放射性碳测年而确定的。中国近海早冰期的低海平面是根据大陆架的残留沉积[21]，贝壳化石[13]，泥炭沉积[3]1) 以及海岸平原的岩芯[1,2]确定的。将可能获得的年代和深度资料综合标绘于图 1。

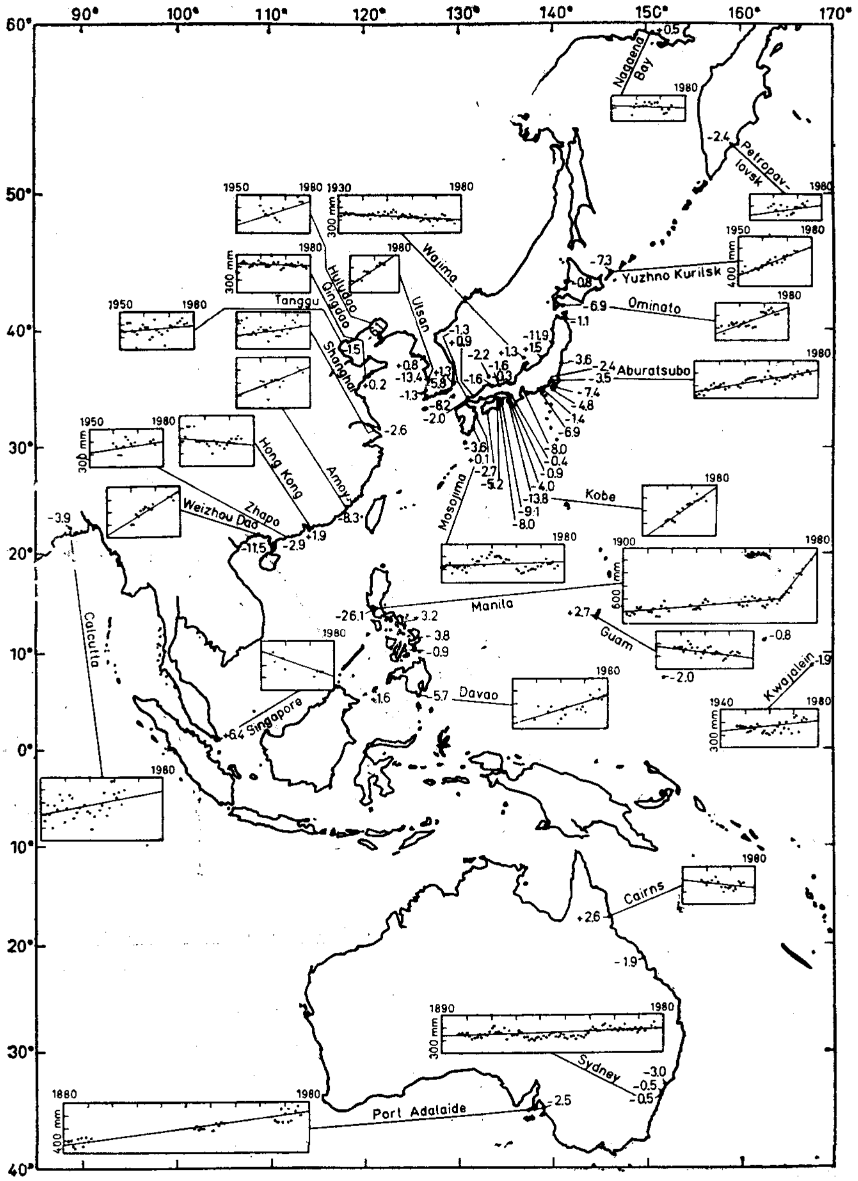

图 2 太平洋西部沿岸验潮站测得的陆地与海平面的相对变化（用毫米/年表示）。方框内的点是年平均水位和根据这些点作出的一元回归直线。基本数据系据 Lennon（1976—1978）和中国科学院海洋研究所。

Fig. 2. Movement of land relative to sea level expressed in terms of mm change per year at many shore stations of the western Pacific Ocean. Representative data in boxes are points for mean annual sea level and a simple regression straight line based upon all points. Basic data are from Lennon (1976—1978) and Institute of Oceanology, Academia Sinica, Qingdao.

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1) 赵松龄、隋道生等，正在准备或付印。

应用验潮仪记录可得出年、月平均海平面，这种海平面相对变化的测定方法比放射性碳测年法更为准确。尽管验潮仪的记录仅有几十年，但其中大多能揭示出由于残留的更新世冰川溶化而使海平面普遍升高的基本趋势。然而，在一些验潮站之间，即使间距只有几十公里，差别却很大。这些复杂情况，是由于曾受冰川冰重压而下降的高纬度陆地的上升，由于返回广阔大陆架的海水重压而使海岸下沉，由于覆盖层的重压和水的排除而使三角洲厚沉积物致密，以及由于伴随褶皱、断裂和火山作用的构造运动而造成的。这些因素在大部分溶水流回海洋之后尤为重要，约在5000年以前，海平面就已接近目前的位置。在那个时期，相对海平面变率的不同表明，认为由于陆地相对于海平面运动的观点更为合适，并以此观点作如下讨论。

近代相对下沉的区域类型

太平洋西部沿岸地区的年平均海平面所依据的验潮记录大多不到40年(图2)，只有3个验潮站(马尼拉、悉尼、阿德莱德港)的记录超过75年。其中，验潮记录超过20年的

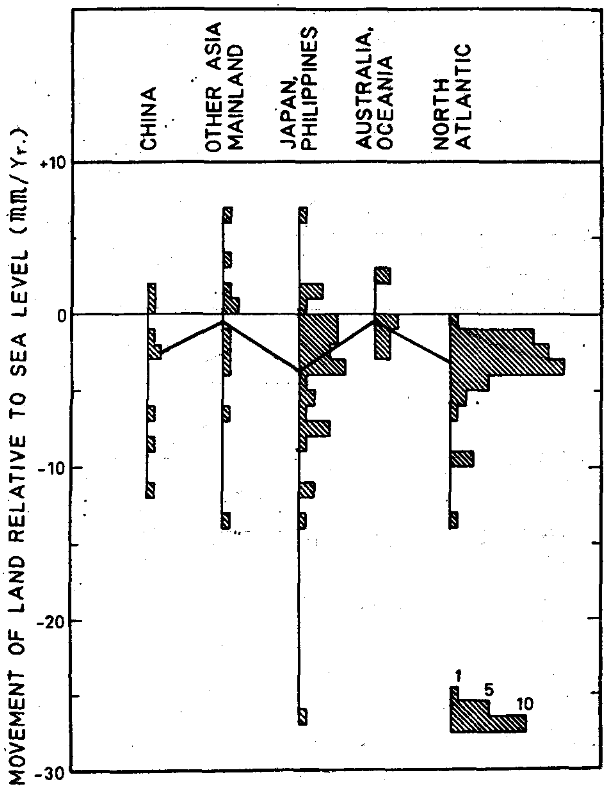

图3　中国以及香港地区8个验潮站测定的陆地相对于海平面的平均年变率，与图2中的其它地区和北纬50°以南、北大西洋北美和欧洲沿岸变化的对比(据 Emery 等待刊稿)。粗线连接的是各地区的平均速率。

Fig. 3. Summary of mean annual rates of land movement relative to sea level at all eight stations of China and Hong Kong District, compared with changes for other regions of Fig. 2 and for North Atlantic coasts south of Lat. 50°N along North America and Europe (from Emery et al. in preparation). Wide line connects median rates in each region.

65个验潮站的数据均已分别点绘成图，做了分析，并用最小二乘法的回归线标明。几乎所有这些验潮站回归线的相关系数，在超过95%的显著水平上，都高于0.50。共有85%的验潮站资料表明了陆地下沉的趋势，其下沉速率用回归线的斜率表示，并以数字标明于相应的岸边(图3)。我们所采用的中国沿岸7个验潮站和香港地区验潮站资料所做回归分析获得的相关系数均较低(只有3个站的相关系数高于0.50)，这可能是由于中国大河的洪水流量引起年平均海平面大幅度变化的缘故。

中国以及香港地区的8个验潮站测出平均相对下沉约 −2.5 毫米/年(图3)，这一数据与北纬50°以南、北大西洋沿岸的北美和欧洲的52个验潮站测得平均相对下沉 −3.0 毫米/年，相差不大(由此可见，基本未受以前冰川覆盖层的影响)，而日本(台站间距很密)和菲律宾(那里的速率差别很大，可能是火山活动的反映)的38个验潮站测得的平均相对下沉率较高，为 −3.6 毫米/年。亚洲中国以南和以北的10个验潮站、澳大利亚和大洋洲的9个验潮站测得的平均相对下沉率较低，为 −0.5 毫米/年，形成一个紧密地区，这可能与这些地区的地质构造稳定有关。

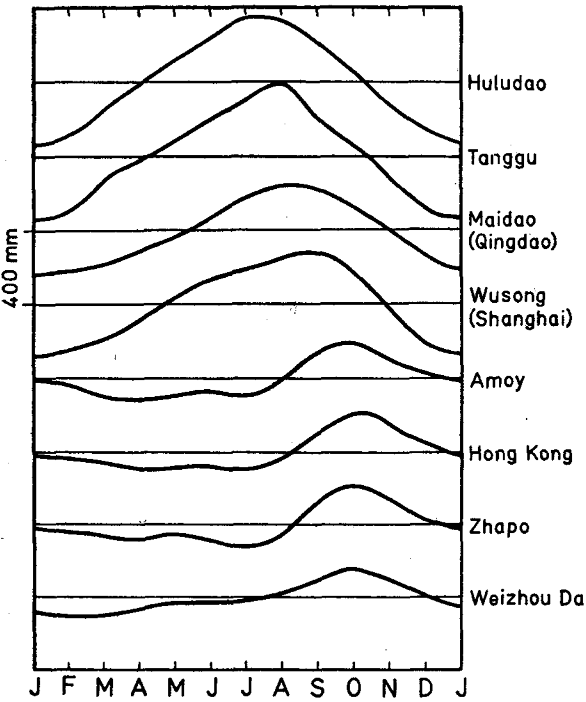

图4 中国7个站和香港1个站月平均海平面的周期变化，数据来源同图2。

Fig. 4. Cyclic variation in monthly mean sea levels at seven tidegauge stations in China and one at Hong Kong District. Same sources as for Fig. 2.

中国的验潮仪记录资料

潮汐知识在中国是不同于欧洲而独立发展起来的。早在公元前200年，中国就十分重视钱塘江涌潮的研究[20]，当认识到涌潮和普通潮汐与月相的相互关系之后，世界上第

一张潮汐表(卢肇)于公元850年问世，并被用来预报海潮。1840年，沈括就指出了当地月中天时刻与高潮时之间的迟角(高潮间隙)。但是，如果没有准确的验潮记录(开始使用验潮仪还不到100年)，对于升降比较缓慢的年平均海平面是难以确定的。即使有验潮仪记录，也还需要经过统计分析，才能导出陆地和海洋平面的相对变化。把每天高低潮之间的几米潮差由每小时的平均潮位转换成日平均海平面，进而再转换成月平均和年平均海平面。中国以及香港地区的8个验潮站，一周年内各月的月平均水位变幅，由北部的约700毫米减至南部的250毫米(图4)。这一结果与Pattullo等人[22]在其世界范围的研究中，根据较少的中国资料所得出的结果很相近。每年月平均水位峰值的出现月份，则从北方的七月中旬向南逐步推迟至十月，这是水位季节振动推移的结果。

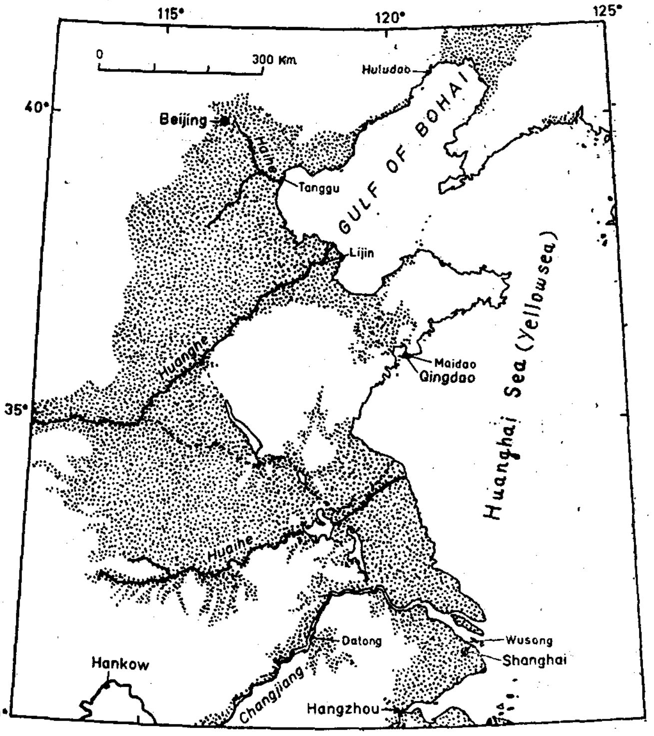

图5　中国北部测站位置、有关城市、主要河流和低洼地(大多是三角洲平原)的分布。低洼地系据中国地质科学院绘制的图幅(1975)。

Fig. 5. Measurement sites, pertinent cities, major rivers, and distribution of lowlands (mostly deltaic plains) are indicated for northern China. Lowlands are from chart by Academy of Geological Sciences of China (1975).

当月平均水位转换成一系列的年平均水位之后，可见年与年之间的变化仅是月变化的百分之几，是日潮差的千分之几。Meade 和 Emery[17] 据统计分析发现美国东部海岸的年变化中，有7—21%是由于河流流量的年变化引起的。比较而言，海平面长期变化的29—83%是由于世纪性的上升引起的。由于中国高度依赖其大江大河和广阔低洼的沿海平原(图5)，因此，在这里我们试图就中国北方引起海平面变化的某些原因做一分析。

现在已有长江和黄河两条最大河流的流量资料。

长江长达 5,796 公里，是中国的重要通航河流。长江口连续不断的泥沙沉积，长期以来造成了海岸和岛屿的变化[5]。黄河略短，长为 5,464 公里，在过去的 4,258 年中，下游走向几经变迁[23]，自 1856 至 1938 年间系经由山东半岛的东南流入黄海，而在 1856 年前和 1938 年后则经由山东半岛的西北流入渤海湾。据报道，以前的三角洲受到侵蚀，而活跃的沉积作用则使现代三角洲向前推进[4]。事实上，目前河床已大大抬高，比其附近的泛滥平原高出 3 到 10 米，河流只是靠在天然堤上加筑人工堤防来控制。对于长江，其 1954—1976 年的流量资料是在大通站(离长江口约 400 公里)取得的；而同期的潮位记录则取自吴淞(在上海和长江口附近)，但这只代表被崇明岛隔开的长江南航道部分的记录。黄河 1950—1975 年的流量资料则取自利津站(离河口约 40 公里)，但其附近没有验潮站，在河口西北约 150 公里(图 2) 的塘沽有 1951—1978 年的验潮记录。根据同时具有潮位和河流流量资料的现实情况，对长江的分析限于 1954—1976 年，而黄河则限于 1951—1975 年。由于年代的跨度短，只能作一比较概括的论述。

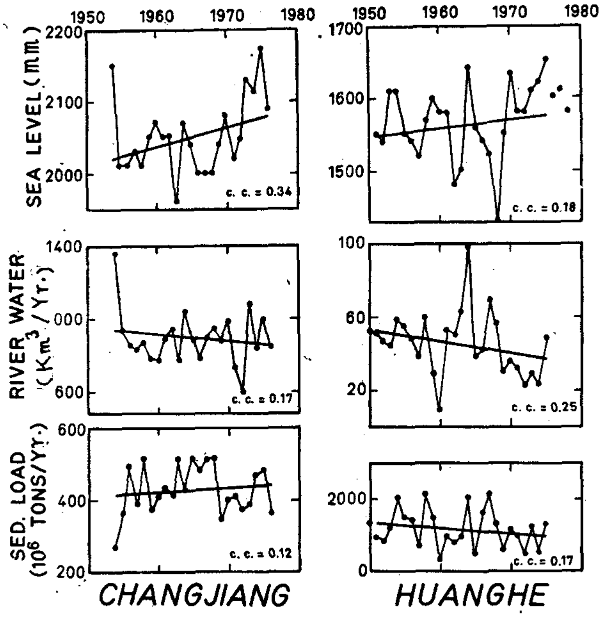

图 6 长江和黄河的年平均海平面(分别在吴淞和塘沽)、年径流量(大通和利津)和年悬移输沙量(汉口和利津)。数据点的回归线是根据同一年代各河流全部数据算得的。

Fig. 6. Annual mean sea levels (at Wusong and Tanggu), annual discharge of water (at Datong and Lijin), and annual discharge of suspended sediment (at Hankow and Lijin) of the rivers Changjiang and Huanghe, respectively. Regression lines for data points are based upon identical years for all data of each river.

对水位和河流流量资料的考察发现，1953—1954、1964 和 1975 年的水位值和流量值均高(图 6)，据知这是由于中国内地异常高的年降雨量造成的。将各河流的流量对其河口附近的海平面进行一元线性回归分析得出，长江的相关系数为 0.58，而黄河仅为 0.11。后者的相关性差，可能是由于在利津的河流水文站与在塘沽的验潮站相距很远，以及大部分河水从河口向东流出的缘故。顺便指出，青岛测得的海平面与黄河流量的相关性高于与长江流量的，其系数分别为 0.27 和 0.06，从而再次支持了黄河水入海后东流的论点[9,21]。黄

河年流量与其年悬移输沙量的相关系数高达 0.73 (图 7)，可能由于二者都在同一地点(利津)测得的缘故。另一方面，长江的悬移输沙量是在汉口测得的，与同一测站测得流量的相关系数为 0.57，而与汉口下游约 600 公里处的大通测得流量的相关系数却为 0.35。据 20 年间的测定，假设不存在沿程灌溉流失和沉积的话，汉口下游流入长江的水量增加了 25%，而输入泥沙只增加 10%。

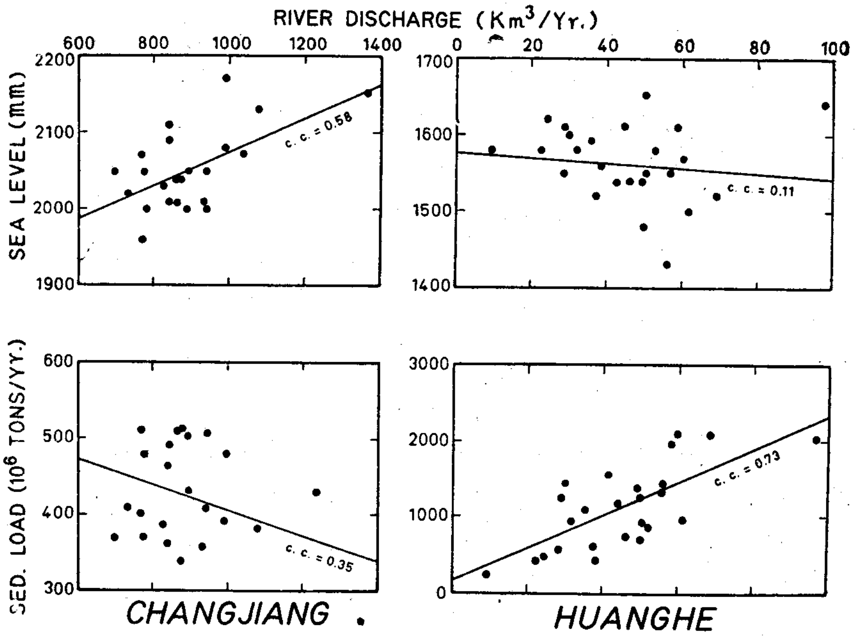

图 7　河流的年径流量与年平均海平面和悬移输沙量(据图 6)的对比。
图中标有回归线的相关系数。

Fig. 7. Comparison of annual river water discharge with annual sea level and annual suspended sediment discharge (From Fig. 6). Correlation coefficients of regression lines are indicated.

将海平面对两大河流的流量和相对应的年代作多元回归分析得出，就长江而言，海平面变化的 53% 是由于流量的变化引起的，11% 是由于附近陆地的相对下沉，其余的 36% 可能是由于风、海流和水温等次要原因引起的。长江是世界第四大河，其流量变化引起海平面变化的比例，大大高于美国大西洋岸较小河流的百分比，这是合理的。黄河与之相对应的百分比是 3%，3% 和 94%。这些百分比低得出奇(与图7中的低相关系数相符)，可能是由于塘沽验潮站远离黄河口和河水入海后远离塘沽而东流的缘故。

设略去年平均海平面年与年之间的变化，那么图 2 回归线所示的中国沿岸的地区差别，系从年平均下沉 −11.5 毫米(涠州岛)到年平均上升 +1.9 毫米 (香港地区)。只有涠州岛、吴淞(−2.6) 和塘沽(−1.5) 三个验潮站是位于深厚的三角洲或三角洲平原上，其它验潮站均设在岩床区，因而不受下垫深厚沉积层致密作用的影响，其变化范围系自 −8.3 到 +1.9毫米/年。三角洲和非三角洲下沉的可靠性对比问题，由于验潮站数量少，垂直运动的方向和变率的范围大，以及验潮记录时间跨度短等原因而受到限制。

一般预测和建议

我们对于全新世海平面上升的了解，仅限于知道大约距今15000年以来才从－150米上升到目前的位置(图1)，如果海平面以均匀速度上升(当然并非如此)，则平均年上升率为10毫米。关于这一上升过程的一个比较合理的看法，是用一近似正弦的曲线表示。这种曲线，系根据放射性碳测年法，对可推定的海岸物质目前所处深度进行测定而制出的。按照这种曲线所示，年平均最大上升率为17毫米，与Milliman和Emery[19]及其它作者绘制的基本海平面上升曲线(图1)所估计的最大上升率相符。同时对盐沼进行的许多放射性碳深度测定结果表明，在过去5000年中，海平面的相对上升平均已减至约1毫米。但是，根据世界大多数验潮仪的测定，这一长期的低上升率，在近几十年中至少提高了一倍，似乎是由于近年冰川消融量的增大，或是由于陆地加快下沉（不大可能）所造成的。实际上，对最近测定的数据检验表明，海平面上升率可能加速[12]。

大气温度主要是由于燃烧化石燃料和制造水泥释放二氧化碳而产生的“温室”效应所控制的。这些二氧化碳可以使阳光通过，但却挡住了较长波的反向热辐射。测定表明，二氧化碳有缓慢的增加，即自1860年的290 ppm，增至目前的335ppm[7,8,14]，与工业革命的兴起相符。根据Manabe和Wetherald[16] Mercer[18]和Woodwell等[25]的计算，按目前产生二氧化碳的增长率，在大约50年内，其浓度将提高一倍。由于二氧化碳的倍增，将导致地球两极的温度升高6—8℃，足以使南极西部不稳定的冰盖迅速溶化，从而使海平面相应升高。地形的迹象表明，冰盖可能已经破裂[24]，而足以表明以前冰盖形状和厚度波动的迹象则依然存在[11]。海平面如果升高5米，将对世界沿海城市，尤其对中国北部沿海的人口稠密区和农业区产生重大影响。实际上，地壳均衡因素表明，太平洋的上升将高于平均上升的高度[10]。

鉴于上述原因，建议中国科学工作者和政府部门认真考虑，增加对河流流量和陆地下沉进行改正后的海平面变动的监测工作，努力研究历史记录，特别是在所有主要大河的活动三角洲上建立新观测站。这是一项艰巨的工作，但如果不做好预测，则海洋对中国海岸带的大海侵，将产生深重的影响。

（秦朝阳译　作者校）

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SEA-LEVEL CHANGES IN THE WESTERN PACIFIC WITH EMPHASIS ON CHINA*

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Low sea levels during Pleistocene glacial stages have been investigated in many studies of the topography and sediments of the world's continental shelves. Melting of the glaciers was accompanied by a rise in sea level from perhaps 150 m below the present level, a position that is indicated by the present depth of relict shore sediments and fossils. Approximate depths and dates of rising sea level are provided by radiocarbon dates of relict or subfossil shore mollusk shells and of peat deposits dredged or cored from the continental shelf. Former glacially-lowered sea levels off China are indicated by relict sediments[21], fossil mollusks[13], and peat deposits[31]1) on the continental shelf, and cores on the coastal plain[1,2]. A summary of available dates and depths is given by Figure 1.

More precise than radiocarbon dates is the measurement of relative change of sea level by means of tide-gauge records, from which mean monthly and mean annual sea levels can be derived. Even though tide-gauge records may span only a few decades, most of them reveal a general rise of sea level attributed to return of meltwater from remaining Pleistocene glaciers. However, rather large differences are exhibited between sites even a few tens of kilometers apart. These complications are due to rise of high-latitude lands formerly downbowed by weight of glacial ice, to coastal down-warping caused by weight of water returned to wide continental shelves, to compaction of thick sediments in deltas because of weight of overburden and withdrawal of fluids, and to tectonic activity associated with folding, faulting, and volcanism. Such factors are especially significant after most of the meltwater had returned to the ocean, and sea level approached its approximate present stand about 5000 years ago. At that stage, differences in direction and rate of relative sealevel change indicate that the changes are better viewed as due to movement of the land relative to sea level——the viewpoint used in the following discussion.

REGIONAL PATTERNS OF RECENT RELATIVE SUBMERGENCE

Mean annual sea levels at coastal sites of the western Pacific Ocean are based upon tide-gauge records mostly shorter than 40 years (Fig. 2). Only three stations (Manila,

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Sydney, and Port Adelaide) have records longer than 75 years. Data for each of the 65 stations having records longer than 20 years were plotted, analyzed, and fitted with a least-squares regression line. In nearly all instances the correlation coefficient of this line is higher than 0.50 —— a level of significance higher than 95%. A total of 85% of the stations reveal subsidence of the land —— at rates indicated in Figure 3 by the slopes of the regression lines and noted by numbers placed along the shores. Correlation coefficients for seven available tide-gauge stations of China and one for Hong Kong are lower (regression lines for only three of the eight stations have correlation coefficients higher than 0.50) probably because large annual ranges in sea level result from flood discharges by the very large rivers of China.

The eight stations of China and Hong Kong denote a median relative subsidence of about −2.5 mm/year (Fig. 3). This is comparable with a median of −3.0 mm/year for 52 stations of North America and Europe that border the North Atlantic Ocean south of Lat. 50°N (and thus essentially unaffected by former burdens of glacial ice). A higher median of −3.6 mm/year is for 38 stations in Japan (a very closely-spaced net) and Philippines (where a large spread in rates probably reflects volcanic activity). Low medians of −0.5 mm/year are for ten stations of Asia north and south of China and nine stations of Australia and Oceania, a tight group perhaps due to tectonic stability of these regions.

DATA OF TIDE-GAUGE RECORDS IN CHINA

Knowledge of the tides was developed in China independently from Europe, with much attention focused upon the tidal bore of the Qiantang River at Hangzhou as early as 200 B.C. (Needham, 1959, p. 483—494). Correlation of the bore and of ordinary tides with phases of the moon was recognized, and by 850 A.D. the world's first tide tables (by Lu Zou) were used to predict the tide. By 1084 the delay constant between transit of the moon past the local meridian and the peak of high tide was defined by Shen Kua. However, the relatively slow rise or fall of relative annual sea level could not be determined without the use of recording tide gauges, which began to be used less than 100 years ago. Even these records require statistical analysis to extract information about changing relative levels of land and ocean surface. The several meters of range between daily low and high tides is reduced by hourly averages to mean daily sea level, and this is further reduced to mean monthly sea level and to mean annual sea level. Mean monthly sea levels plotted for the entire year at the eight stations of China and Hong Kong have a range that decreases from about 700 mm at the north to 250 mm at the south (Fig. 4). Results are rather similar to those obtained by Pattullo et al.[22] in their world study that contained fewer data for China. Peaks in sea level are progressively delayed from mid-July in the north to October in the south —— the result of progressing dates of seasonal oscillation.

After the mean monthly sea levels are reduced to a series of mean annual sea levels, a year-to-year variation remains that is a few per cent of the monthly variation and a few tenths of a per cent of the daily tidal range. Meade and Emery[17] found by statistical analysis that 7 to 21% of the annual variation along the coast of eastern United States is due to annual variations in river runoff. In comparison, 29 to 83%

of the long-term change in sea level is due to secular rise. Because China is highly dependent upon its large rivers and its broad low coastal plains (Fig. 5), an analysis of some of the components of changing sea level was attempted here for northern China.

Data are available for water discharge of the two largest rivers, Changjiang (Yangtze River) and Huanghe (yellow River). The Changjiang River is 5796 km long and is the main navigable river of China. Continuous deposition of sediment at its mouth has produced a long record of shore and island changes[25]. The Huanghe River, only slightly shorter at 5464 km, has undergone many course changes during the past 4258 years[23], having entered the Huanghai sea (Yellow Sea) at a point southeast of the Shandong Peninsula between 1856 and 1938, and entered the Bohai Bay northwest of the peninsula prior to 1856 and after 1938. Erosion is reported at the former delta, and active deposition is prograding the present delta[4]. In fact, the floor of the river has aggraded so much that now it is 3 to 10 m above the adjacent flood plain, and the river is confined only by natural levees surmounted by artificial ones. For the Changjiang River, discharge data for 1954—1976 are from Datung (about 400 km from the mouth). Sea-level records for the same years are from Wusong (near Shanghai and near the mouth), but they are for only the southern division of the river that divides to pass around the island of Chongming Island. For the Huanghe River, discharge data for 1950—1975 are from Lijin (about 40 km from the mouth), but no tide-gauge station is near. Tide-gauge records from Tanggu about 150 km northwest (Fig. 2) are available for 1951—1978. The years for which matching data exist for both sea level and river-water discharge limits the analysis to 1954—1976 for the Changjiang River and 1951—1975 for the Huanghe River. These time spans are too short to permit the making of more than broad generalization.

Examination of data for sea levels and river-water discharge shows that high values for both occurred in 1953—1954, 1964, and 1975 (Fig. 6), known to be years of unusually high precipitation in the interior of China. Simple linear regression analyses of the volume of water discharged by each river versus sea level near the mouth yield correlation coefficients of 0.58 for the Changjiang River and 0.11 for the Huanghe River. The poor correlation for the Huanghe River probably is due to the large distance between the river gauging station at Lijin and the tide gauge at Tanggu, as well as to escape of most water eastward from the Huanghe mouth. Incidentally, the sea levels at Qingdao correlate better with the river discharges of the Huanghe River than with those of the Changjiang River——0.27 versus 0.06——again supporting the concept of eastward flow of Huanghe River discharge[9,21]. The correlation coefficient of annual suspended sediment load with annual water discharge for the Huanghe River is high (0.73—Fig. 7), perhaps because both were measured at the same site, at Lijin. On the other hand, the sediment load for the Changjiang River was measured at Hankow, and it has a correlation coefficient of 0.57 with the water discharged measured at Hankow but only one of 0.35 at Datung (Fig. 7), about 600 km downriver. During the two decades of these measurements 25% more water was added to the Changjiang downriver from Hankow but only about 10% more sediment, assuming no losses by irrigation or deposition en route.

Multiple regression analyses were made for sea levels versus water discharges of the two major rivers versus time in years. For the Changjiang the analysis indicates that 53% of the sea level variations can be attributed to variations in water discharge, 11% to relative subsidence of the land, and the remainder (36%) to other unspecified causes —— probably wind, currents, and water temperature. The 53% due to variations in water discharge of the Changjiang River (fourth largest river in the world) is reasonable and much higher than for the smaller rivers along the Atlantic coast of the United States. For the Huanghe River, corresponding figures are 3%, 3%, and 94%. These percentages are ridiculously low, corresponding with the low correlation coefficient in Figure 7, probably because of the distance of the Tanggu tide gauge from the mouth of the Huanghe River and the flow of discharged water eastward away from Tanggu.

Regardless of the year-to-year variations in mean annual sea level, the regression lines of Figure 2 show regional differences along the China coast that range from − 11.5 mm/year of subsidence (Weizhou Island) to + 1.9 mm/year of emergence (Hong Kong). Only Weizhou Island, Wusong (− 2.6), and Tanggu (− 1.5) are on thick deltas or deltaic plains. All other stations are in regions of bedrock and thus are unaffected by compaction of underlying thick sediments; their rates range from − 8.3 to + 1.9 mm/year. Reliable comparison of deltaic and non-deltaic subsidence is prevented by the small number of stations, the wide range in direction and rate of vertical movement, and the short time span for the tide-gauge records.

GENERAL PREDICTIONS AND RECOMMENDATIONS

The Holocene rise of sea level is known only in general outline as having risen from about − 150 m to the present level in about 15,000 years (Fig. 1). If it had risen at a uniform rate (which it certainly did not do), the rate would have been 10 mm/year, a more reasonable view of the rise (and one that generally is supported by existing radiocarbon measurements of age versus present depth of datable shoreline materials) is that of an approximate sine curve. The maximum rate of rise following such a curve would be 17 mm/year, and this corresponds well with the maximum rate estimated from the general sea-level-rise curve (Fig. 1) drawn by Milliman and Emery[19] and from those of other authors. During the past 5000 years the relative rise of sea level was reduced to a mean of perhaps 1 mm/year on the basis of many radiocarbon-depth measurements in salt marshes. This low long-term rate, however, appears to have at least doubled during the few decades spanned by most tide-gauge measurements of the world as though due to recently increased melting of glaciers or to increased subsidence of land (less likely). In fact, an examination of recent measurements indicates a possible acceleration in the rate of sea-level rise[12].

A major control over the temperature of the atmosphere appears to be the "greenhouse" effect produced by carbon dioxide liberated by the burning of fossil fuels and the making of cement. This carbon dioxide allows sunlight to pass but retains much of the longerwavelength heat from back radiation. Measurements indicate a slow increase in carbon dioxide from about 290 ppm in 1860 to 335 ppm at present[7,8,14], corresponding with the onset of the Industrial Revolution. Calculations by Manabe and Wetherald[16], Mercer[18] and Woodwell et al.[25] suggest that a doubling of the carbon dioxide concentration may occur within about 50 years at the present rate of increase in its production. This doubling would produce a warming at the poles of the Earth of 6—8°C, enough to cause rapid melting of the unstable West Antarctica ice sheet and a corresponding rise of sea level. Topographic evidence indicates that this ice sheet may already be breaking up[24], and evidence exists of previous fluctuations in its size and thickness[11]. A 5 m rise of sea level will have very important effects upon coastal cities of the world, and particularly upon the densely populated and cultivated coastal regions of northern coastal China. In fact, isostatic factors indicate that the rise over the Pacific Ocean will be higher than the average rise[10].

For these reasons it is suggested that scientists and government bureaus of China seriously consider increased monitoring of sea-level changes corrected for river runoff and land subsidence. An effort should be made to search for older records and to eatablish new stations particularly upon the active deltas of all major rivers. This is not an easy task, but the importance of a major transgression of the coastal zone of China by the ocean will have far-reaching effects especially if it is not anticipated.

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