**The Geologic History of the Mediterranean**

**地中海的地质历史**

In 1970 geologists Kenneth J. Hsu and William B.F. Ryan were collecting research data while aboard the oceanographic research vessel Glomar Challenger. An objective of this particular cruise was to investigate the floor of the Mediterranean and to resolve questions about its geologic history. One question was related to evidence that the invertebrate fauna (animals without spines) of the Mediterranean had changed abruptly about 6 million years ago. Most of the older organisms were nearly wiped out, although a few hardy species survived. A few managed to migrate into the Atlantic. Somewhat later, the migrants returned, bringing new species with them. Why did the near extinction and migrations occur?

1970年，地理学家Kenneth J. Hsu 和William B.F. Ryan在海洋调查船Glomar Challenger号上收集调研资料。这次特别巡航的一个目的是调查地中海的地层以及解决关于其地质历史的问题。其中一个问题是有关地中海地区无脊椎动物（没有脊椎的动物）于600万年前发生剧变的证据。大部分更古老些的生物都几乎灭绝了，尽管有少数顽强的种类幸存了下来。很少的一些动物成功地迁移到了大西洋。不久后，这些动物又回来了，并带回了新的物种。为什么这次距今较近的动物灭绝和迁移会发生呢？

■Another task for the Glomar Challenger’s scientists was to try to determine the origin of the dome-like masses buried deep beneath the Mediterranean seafloor. ■These structures had been detected years earlier by echo-sounding instruments, but they had never been penetrated in the course of drilling. ■Were they salt domes such as are common along the United States Gulf Coast, and if so, why should there have been so much solid crystalline salt beneath the floor of the Mediterranean? ■

Glomar Challenger号上的科学家们的另一个任务是尝试去确定深埋在地中海海底穹顶状巨块的起源。这些结构在早些年被回声探测器探测过，但是它们从未被钻探过。它们是像美国墨西哥海湾海岸一带的含盐穹顶状巨块吗？如果是的话，为什么在地中海海底之下会有这么多固体的结晶盐呢？

With question such as these clearly before them, the scientists aboard the Glomar Challenger processed to the Mediterranean to search for the answers. On August 23, 1970, they recovered a sample. The sample consisted of pebbles of gypsum and fragments of volcanic rock. Not a single pebble was found that might have indicated that the pebbles came from the nearby continent. In the days following, samples of solid gypsum were repeatedly brought on deck as drilling operations penetrated the seafloor. Furthermore, the gypsum was found to possess peculiarities of composition and structure that suggested it had formed on desert flats. Sediment above and below the gypsum layer contained tiny marine fossils, indicating open-ocean conditions. As they drilled into the central and deepest part of the Mediterranean basin, the scientists took solid, shiny, crystalline salt from the core barrel. Interbedded with the salt were thin layers of what appeared to be windblown silt.

带着这些清楚摆在他们面前的问题，科学家们登上Glomar Challenger号前往地中海寻找答案。1970年8月23日，他们找到了一个样本。这个样本由石膏块和火山岩碎块组成。周围没有发现一块能说明这些小石头是来自附近大陆的石头。接下来的日子里，随着海底岩层钻探实验的进行，固体石膏样本被不断地放在甲板上。而且，这些膏状物的组成和结构特性表明它们形成于沙漠。在石膏层上下的沉积物中包含了微小的海洋生物化石，说明了这是开放性的海洋环境。当钻到地中海盆地中心的最深处时，科学家们从钻管中获得了坚实的、光亮的结晶盐。跟结晶盐嵌在一起的薄层像是被风吹起的泥沙层。

The time had come to formulate a hypothesis. The investigators theorized that about 20 million years ago, the Mediterranean was a broad seaway linked to the Atlantic by two narrow straits. Crustal movements closed the straits, and the landlocked Mediterranean began to evaporate. Increasing salinity caused by the evaporation resulted in the extermination of scores of invertebrate species. Only a few organisms especially tolerant of very salty conditions remained. As evaporation continued, the remaining brine (salt water) became so dense that the calcium sulfate of the hard layer was precipitated. In the central deeper part of the basin, the last of the brine evaporated to precipitate more soluble sodium chloride (salt). Later, under the weight of overlying sediments, this salt flowed plastically upward to form salt domes. Before this happened, however, the Mediterranean was a vast desert 3,000 meters deep. Then, about 5.5 million years ago came the deluge. As a result of crustal adjustments and faulting, the Strait of Gibraltar, where the Mediterranean now connects to the Atlantic, opened, and water cascaded spectacularly back into the Mediterranean. Turbulent waters tore into the hardened salt flats, broke them up, and ground them into the pebbles observed in the first sample taken by the Challenger. As the basin was refilled, normal marine organisms returned. Soon layer of oceanic ooze began to accumulate above the old hard layer.

时间阐明了一个假设。调查者们构思了这样的理论：大约2 ,000万年前，地中海是一条宽阔的航道，它通过两条狭窄的海峡与大西洋连接。地壳运动封闭了海峡，被陆地包围的地中海也开始蒸发。由蒸发引起的越来越高的盐度造成大量无脊椎动物种类的灭绝。只有一些能抵抗高盐度条件的物种保留下来。随着蒸发的继续进行，盐水浓度太高以致硬地层的硫酸钙发生沉淀。在盆地的中间深处，剩余盐水的持续蒸发形成更多的可溶的氯化钠（盐）。后来，在上层沉淀物的重压下，盐向上形成了含盐的圆顶。然而在这之前，地中海是一个3 000米深的大沙漠。然后，550万年前发生了洪水。作为地壳调整和断层作用的结果，现在连接地中海和大西洋的直布罗陀海峡打开了，水流像瀑布一样壮观地涌回地中海。湍急的水流冲击并摧毁了坚硬的含盐层，把它们磨成了Challenger号获得的第一份样本中人们所观察到的鹅卵石。随着盆地的填充，普通的海洋生物又回来了。不久后海洋软泥层开始在原先的硬地层上堆积。

The salt and gypsum, the faunal changes, and the unusual gravel provided abundant evidence that the Mediterranean was once a desert.

盐、石膏、动物区系的变更，还有不寻常的沙砾层都为地中海曾经是片沙漠的理论提供了充分的证据。

gypsum: a mineral made of calcium sulfate and water