Ancient continents, clues to the geoid, and polar wander

If you took a model of the globe, stopped its rotation and surface processes, and covered the whole smooth sphere with water, you would have a theoretical tool, called a geoid, to study the earth's distributions of density. When real distributions in the earth's mass are added to the model, the earth's density undulates, up 120 meters over New Guinea, down about 130 meters over Antarctica. The total amplitude of changes in distributions of mass is more than 240 meters, with areas of high density — the Atlantic-African geoid high and the Pacific geoid high — centered on opposite sides of the world. But the shape of the geoid bears little relation to the location today of surface features such as continents and oceans.

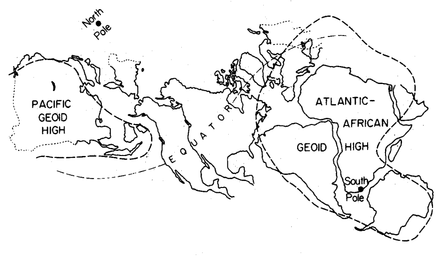
In a paper published in the June 3 NATURE, Don L. Anderson of the California Institute of Technology tackles many of the questions raised by the geoid. His explanations include speculative answers to a good number of long-standing problems in the earth sciences, from hotspots to shifts in the rotation axis of the earth. The paper was presented at the recent meeting in Philadelphia of the American Geophysical Union.

Anderson's main theme is that the geoid highs are signatures marking the locations of ancient supercontinents. Reconstructions of Pangea, for instance, show that about 150 million years ago, most large pieces of the earth's continental shields — regions of extremely thick lithosphere — were contained within the Atlantic-African geoid high. He also suggests that perhaps pieces of continent rimming the Pacific today once were assembled into a land mass centered over the Central Pacific geoid high still observed.

Anderson argues that the continents are responsible for determining the distributions of mass. Brad Hager of Caltech concurs that the dense crustal material would insulate the mantle, causing heat to build up. The heating then would cause uplift, and the uplift would cause the geoid high. The insulation, Anderson writes, also could cause hotspots, the relatively fixed spots where magma pushes through the mantle (SN: 9/22/79, p. 202; 12/19/81, p. 388). When the mantle beneath the land mass heated to a sufficient degree, volcanism would result.

The argument that hotspots are caused by continental insulation is persuasive because most of the oceanic hotspots, such as those in the Hawaii-Emperor chain, are located in areas of high mass distribution, and away from trenches where cold oceanic lithosphere is being subducted into the mantle. The suggestion also supports the idea that magma emitted at hotspots may come from below the plates and from a different source than magmas at ridges where crustal plates are spreading apart.

The hotspots and the geoid highs may represent convection between the core-mantle boundary and 700 kilometers depth, says Clement Chase of the University of Minnesota. "If Pangea was in place long enough it may well have affected this deeper pattern of convection and caused it to rearrange itself and come up in a different place. Looking closely at the paleomagnetic records from the continents may help determine the case."



Anderson/Nature

Suggested placement of continents about 220 million years ago (late Paleozoic) with regard to current residual geoid highs and the Paleoequator. India and Australia not shown.

Chase cites the record of changes in the earth's axis of rotation as a sign that geoid highs and lows are long-lived features. "If the geoid changes its shape abruptly and by very large amounts, the rotational pole of the earth will follow it. There is no evidence that this has happened," he said.

Many of the suggestions regarding hotspots, continental breakup and polar wander are not new, Anderson writes. "What is new is the suggestion that continents cause geoid anomalies and hotspots and, indirectly, control the rotation axis of the earth."

The ideas in Anderson's paper and their relationship to convection in the mantle, configuration of ancient land masses and the history of true polar wander — the net rotation of the entire shell of the earth relative to the paleomagnetic rotational poles — may provide material for spirited debate among earth scientists. Chase, who generally agrees with Anderson's explanation of the geoid, says, "It's quite likely that he is right; it is also quite likely that he's wrong." There are a lot of places, he says, to start making measurements to quantify it more exactly. *—C. Simon*

Sizing up the satellites of Uranus

Three University of Hawaii astronomers have made what they say are the first measurements of the sizes of four of the five known moons of Uranus. Twice as far from earth as is Saturn, the Uranian moons appear too small to show up as clear disks in photos taken through even large telescopes. Heretofore, astronomers could only measure each moon's visible-light brightness as a point of light and then try to guess whether that brightness was being produced by a small, shiny surface or a large, dark one. The Voyager spacecraft findings about the moons of Jupiter and Saturn, whose surfaces run the gamut from ice to rock to sulfur, have shown such assumptions to be a risky business.

The newly measured diameters (see chart) were made possible by the National Aeronautics and Space Administration's Infrared Telescope Facility, operated for NASA by the university on Mauna Kea. Only three years old, and recently equipped with improved IR detectors, the sensitive instrument was used by the university's R. Hamilton Brown, Dale P. Cruikshank and David Morrison to record 20-micron thermal emissions from Ariel, Umbriel, Titania and Oberon. (Miranda is too close to Uranus to be detected over the planet's own IR emissions.) "It sort of boggles my mind," says Morrison, "that one is able to measure the heat radiating from objects that are colder than liquid nitrogen." Knowing the IR temperatures (representing re-emitted solar energy) enabled the researchers to determine where each satellite's visible brightness (measured with the university's 2.2-meter telescope, also on Mauna Kea) placed it in the balance between size and shininess. The same calculations yielded each moon's mean geometric albedo, or reflectivity, now being studied by Brown in an effort to understand the surface compositions.

Satellite	**Diameter** (km)	**Mean Geometric Albedo**
Ariel	1410 ± 105	.34
Umbriel	1160 ± 90	.23
Titania	1670 ± 90	.27
Oberon	1690 ± 110	.22

A key use of the diameter measurements will be to help aim the cameras of the Voyager 2 spacecraft, which will fly past Uranus and its moons in January of 1986. Titania, for example, will fill 60 percent of the width of one of Voyager's narrow-angle photos, says Charles Kohlhase of Jet Propulsion Laboratory, and the probe will come no closer than 372,000 kilometers, so even a slight aiming error could cut part of the subject out of the picture. The albedo measurements will be used in calibrating the cameras' exposure settings.

Ironically, NASA's fledgling IR telescope may not have much time to follow up its latest accomplishment. Funded by the agency's financially pressed planetary division, it is listed in the Reagan administration's proposed FY 1983 budget to be mothballed by year's end. *—J. Eberhart*