U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

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SMITHSONIAN INSTITUTION and the U.S. NAVAL RESEARCH LABORATORY

GEOLOGIC INVESTIGATIONS SERIES
MAP I-2800

EURASIA PLATE
NORTH AMERICA PLATE
PACIFIC PLATE
PHILIPPINE PLATE
CARIBBEAN PLATE
COCOS PLATE
NUBIA PLATE
ARABIA PLATE
INDIA PLATE
SOMALIA PLATE
SOUTH AMERICA PLATE
NAZCA PLATE
AUSTRALIA PLATE
ANTARCTICA PLATE
SCOTIA PLATE

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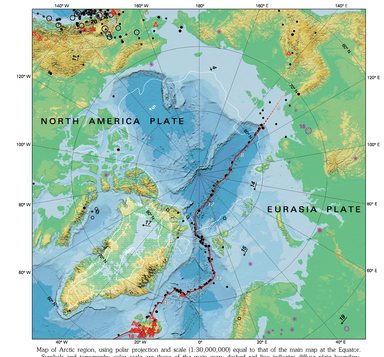
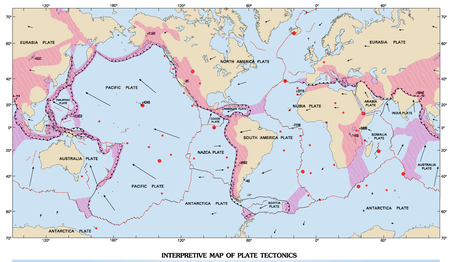


Map of Arctic region, using polar projection and scale (1:30,000,000) equal to that of the main map at the Equator. Symbols and topography color scale are those of the main map; dashed red line indicates diffuse plate boundary. Bathymetry from International Bathymetric Chart of the Arctic Ocean. "Snowflake" stipple indicates Greenland's glacial ice cap, with its surface contours (in meters) shown in white. Ice-surface and sub-ice topography from the [U.S.] National Snow and Ice Data Center. Dashed white line shows the minimum limit of sea ice (1972–2003 average) from the [U.S.] National/Naval Ice Center.



INTERPRETIVE MAP OF PLATE TECTONICS

Divergent plate boundary—Where new crust is generated as the plates pull away from each other

Convergent plate boundary—Where crust is recycled as one plate dives under another (in the direction shown by sawteeth)

Transform plate boundary—Where crust is neither produced nor consumed as plates slide horizontally past each other

Selected fossil boundary—Former plate boundary, now inactive; evidence that plate boundaries are not permanent

Diffuse boundary zone—Broad belt in which deformation occurs over a wide region (from Gordon, 2000), may encompass one or more smaller plates

Selected hotspots—Larger symbol indicates major hotspot; smaller symbol indicates minor hotspot

Plate motion—Length of arrow is roughly proportional to the rate of plate motion (longer=faster; see main map for details)

Elevation—Highest (+) and lowest (-) points, in meters, on four largest continents and in two oceans

TOPOGRAPHY: DEPTH AND ELEVATION IN METERS

Sea-floor data from Scripps Institution of Oceanography Web site "Satellite Geodesy" (http://topex.ucsd.edu/marine_topo/mar_topo.html), accessed June 11, 1997; land-elevation data from U.S. Geological Survey (1997). Most lakes are shown in pale blue, with depth not implied. For the world's largest inland sea (Caspian) and deepest lake (Baikal), however, actual lake floor topography is shown using the same color scale as for the rest of the map.

0 200 400 600 800 1000 1200 KILOMETERS
EQUATOR
0 200 400 600 800 1000 1200 KILOMETERS

MERCATOR PROJECTION
Scale 1:30 000 000 at the Equator
One centimeter equals 300 kilometers (186 miles) at the Equator
One inch equals 473 miles (~762 kilometers) at the Equator

Suggested citation: Simkin, Tom, Tilling, R.I., Vogt, P.R., Kirby, S.H., Kimberly, Paul, and Stewart, D.B., 2006, This dynamic planet; World map of volcanoes, earthquakes, impact craters, and plate tectonics: U.S. Geological Survey Geologic Investigations Series Map I-2800, 1 two-sided sheet, scale 1:30,000,000

Volcanoes—Data from Global Volcanism Program, Smithsonian Institution, Washington, D.C., accessed at http://www.volcano.si.edu/world/summary.cfm , March 16, 2005

▲ Erupted A.D. 1900 through 2003
△ Erupted A.D. 1 through 1899
△ Erupted in Holocene time (past 10,000 years), but no known eruptions since A.D. 1
▵ Uncertain Holocene activity and fumarolic activity

Impact Craters—Data from University of New Brunswick, Planetary and Space Science Centre, Earth Impact Database; accessed at http://www.unb.ca/passc/ImpactDatabase/, October 23, 2003 (also see Grieve, 1998). Geologic age span: 50 years to 2,400 million years. Crater diameter indicated below

+ <10 km
✳ 10 to 70 km
○ >70 km (shown at actual map scale)

Notable Events—Numbers next to a few symbols—of many thousands shown—denote especially noteworthy events, keyed to correspondingly numbered entries in tables found on the back of the map. These numbered events have produced devastating natural disasters, advanced scientific understanding, or piqued popular interest. They remind us that the map's small symbols may represent large and geologically significant events

19 Volcanoes
9 Earthquakes
23 Impact craters

Plate Tectonics

100 Divergent (sea-floor spreading) and transform fault boundaries—Red lines mark spreading centers where most of the world's volcanism takes place; thickness of lines indicates divergence rate, in four velocity ranges. White number is speed in millimeters per year (mm/yr) from DeMets and others (1994). The four spreading-rate ranges are <30 mm/yr, 30–59 mm/yr, 60–90 mm/yr, and >90 mm/yr. Thin black line marks the plate boundary, whether sea-floor spreading center or transform fault. On land, divergent boundaries are commonly diffuse zones (see interpretive map to the left); therefore, most are not shown. The only transform faults shown on land are those separating named plates

9 Plate motion—Data from Rice University Global Tectonics Group. Length of arrow is proportional to plate velocity, shown in millimeters per year. These approximate rates and directions are calculated from angular velocities with respect to hotspots, assumed to be relatively fixed in the mantle (see plate motion calculator at http://tectonics. rice.edu/hs3.html)

46 Plate convergence—More accurately known than "absolute" plate motion (above), convergence data are shown by arrows of uniform length showing direction and speed, in millimeters per year, relative to the plate across the boundary. Data from Charles DeMets (University of Wisconsin at Madison, written commun., 2003) and Bird (2003)

Earthquakes—Data from English and Villaseñor (2002). From 1900 through 1963, the data are complete for all earthquakes ≥6.5 magnitude; from 1964 through 1999, the data are complete for all earthquakes ≥5.0 magnitude. Most location uncertainties <35 km. Eleven more recent major or great earthquakes (magnitude ≥7.7) have been added for completeness through 2004; data from USGS National Earthquake Information Center at http://neic.usgs.gov/ , accessed January 4, 2005. An epicenter is the surface location of the first rupture on an earthquake fault. Symbols shown represent epicenters. For earthquakes larger than about magnitude 7.0, the size of the rupture zone, which can extend hundreds of kilometers from the epicenter, is larger than the symbols used on this map

Depth to earthquake, in km	Magnitude of earthquake			
	5.0–5.9	6.0–6.9	7.0–7.9	≥8.0
<60	•	•	○	○
60–300	•	•	○	○
>300	•	•	○	○
Global average occurrence*	1319/yr	134/yr	17/yr	1/yr

*Earthquakes of magnitude >5 but shown on map are much more frequent, with ~13,000/yr in the 4.0–4.9 range alone. Data from USGS National Earthquake Information Center.

○ Earthquakes that occurred from 1750 to 1963 within stable plate interiors on continents—Data from A.C. Johnston (Center for Earthquake Research and Information, University of Memphis, written commun., 2002). Even though these epicenters do not meet the precise location criteria of English and Villaseñor (2002), they are plotted here to remind readers of the potentially hazardous earthquakes that are distant from known plate boundaries. Size of symbol proportional to earthquake magnitude

○ Notable pre-1900 earthquakes—Nos. 1, 2, 3, 6, and 7 (see table 3, on back)

THIS DYNAMIC PLANET

WORLD MAP OF VOLCANOES, EARTHQUAKES, IMPACT CRATERS, AND PLATE TECTONICS

By

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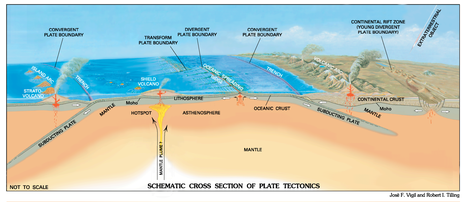
2006

ABOUT THIS MAP

This map shows many of the features that have shaped—and continue to change—our dynamic planet. Most new crust forms at ocean ridge crests, is carried slowly away by plate movement, and is ultimately recycled deep into the Earth—causing earthquakes and volcanism along the boundaries between moving tectonic plates. Oceans are continually opening (for example, Red Sea, Atlantic) or closing (for example, Mediterranean). Because continental crust is thicker and less dense than younger oceanic crust, most does not sink deep enough to be recycled and remains largely preserved on land. Consequently, most continental bedrock is far older than the oldest oceanic bedrock (see inset IV, on back).

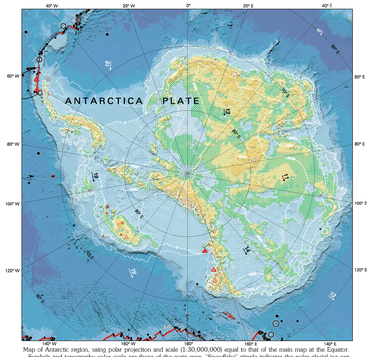
The earthquakes and volcanoes that mark plate boundaries are clearly shown on this map, as are craters made by impacts of extraterrestrial objects that punctuate Earth's history, some of which have caused catastrophic ecological changes. Over geologic time, continuing plate movements, together with relentless erosion and redeposition of material, mask or obliterate traces of earlier plate-tectonic or impact processes, making the older chapters of Earth's 4,500-million-year history increasingly difficult to read. The recent activity shown on this map provides only a present-day snapshot of Earth's long history, helping to illustrate how its present surface came to be.

The map is designed to show the most prominent features when viewed from a distance, and more detailed features upon closer inspection. The back of the map zooms in further, highlighting examples of fundamental features, while providing text, timelines, references, and other resources to enhance understanding of this dynamic planet. Both the front and back of this map illustrate the enormous recent growth in our knowledge of planet Earth. Yet, much remains unknown, particularly about the processes operating below the ever-shifting plates and the detailed geological history during all but the most recent stage of Earth's development.



Joel F. Vigil and Robert I. Tilling

An interactive Web-based version of this map—front and back—can be accessed at http://www.minerals.si.edu/ldpmap. This Web site also contains a listing of Web addresses of other data sources used in this map plus useful sites for additional information.



Map of Antarctic region, using polar projection and scale (1:30,000,000) equal to that of the main map at the Equator. Symbols and topography color scale are those of the main map. "Snowflake" stipple indicates the polar glacial ice cap with sub-ice topography beneath, ice-surface contours (in meters) are shown in white. Data were compiled by the British Antarctic Survey. Dashed white line shows the minimum limit of sea ice (1972–2003 average) from the [U.S.] National/Naval Ice Center. Topography and shorelines would be quite different if Antarctica's glacial ice melted completely. Sea level would rise globally as much as 65 m, and the continent would rebound by about 1 km, in response to the removal of the ice load.

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Smithsonian Institution
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