Table 1. Notable IMPACTS
[* Not included on published map. Ma = million years ago. D = diameter.]

No.	Crater (location)	Date	Importance	Lat	Long
1*	Suavjärvi (Russia)	~2400 Ma	Apparently the oldest known crater, it is still recognizable despite obscuring by post-impact geological processes.	63.1 N	33.4 E
2	Vredefort (South Africa)	2023 ± 4 Ma	Largest known structure (D=300 km); unique textural features indicate high-pressure shock impact.	27.5 S	27.5 E
3	Sudbury (Ontario, Canada)	1850 ± 3 Ma	This large crater (D=200 km) is the only one with shock-melted body that hosts rich nickel-copper ore deposits.	46.6 N	81.2 W
4*	Shoemaker (Australia)	1630 ± 5 Ma	Fourth oldest of ~170 known craters; named for the late Eugene Shoemaker, "Father of planetary geology."	25.9 S	120.9 E
5*	Acraman (Australia)	~590 Ma	Discovered by identifying and mapping distant impact breccia layer in surrounding late pre-Cambrian rocks.	32.0 S	135.5 E
6*	Lockne (Sweden)	>455 Ma	Impacting bolide entered shallow water; key features of resulting crater now preserved on uplifted land.	63.0 N	14.8 E
7*	Brent (Ontario, Canada)	396 ± 20 Ma	Pioneering Canadian studies in 1950s and 1960s of this buried structure advanced understanding of impact processes.	46.1 N	78.5 W
8	Clearwater (Quebec, Canada)	290 ± 20 Ma	Rare paired craters (D= 26 and 36 km) formed by two close but separated bolides.	56.2 N	74.5 W
9*	Araguinha (Brazil)	244.4 ± 3.25 Ma	Largest crater in South America; tree cover makes craters hard to find in the tropics, and few are known.	16.8 S	53.0 W
10*	Manicouagan (Quebec)	214 ± 1 Ma	Deep erosion has revealed Earth's only complex, multi-ring structure common on the moon.	51.4 N	68.7 W
11*	Puchezh-Katunki (Russia)	167 ± 3 Ma	Among the eight largest craters known, this is the smallest (D=80 km) shown at true scale on main map.	57.0 N	43.7 E
12*	Chukcha (Russia)	<70 Ma	Northernmost crater known (see Arctic map). Ice hides (and erodes) many craters at high latitudes.	75.7 N	97.8 E
13	Chicxulub (Mexico)	64.98 ± 0.05 Ma	Produced K/T (dinosaur) extinction event and global ejecta (with fingerprint iridium layer); see Inset VI.	21.3 N	89.5 W
14	Montagnais (Nova-Scotia)	50.50 ± 0.76 Ma	First crater recognized at sea (buried on continental shelf); nearly all other known craters are on land.	42.9 N	64.2 W
15	Wanapitei (Ontario)	37.2 ± 1.2 Ma	Younger, smaller crater inside Sudbury (no.3); only known example of a second impact in the same place.	46.8 N	80.8 W
16	Popigai (Russia)	35.7 ± 0.2 Ma	Detailed studies of this large (D=100 km) crater discovered diamonds produced by high-pressure shock waves.	71.6 N	111.2 E
17	Chesapeake Bay (Virginia, USA)	35.5 ± 0.3 Ma	Largest crater in USA (D=85 km), buried by younger sediments, was discovered in 1980s by geophysical surveys.	37.3 N	76.0 W
18*	Ries (Germany)	15.1 ± 0.1 Ma	New rock type, suevite, a mix of broken bedrock fragments and impact-melt glass, discovered in well-studied crater.	48.9 N	10.6 E
19*	Bosumtwi (Ghana)	1.07 Ma	Source of tektites–small, glassy blobs of impact melt strewn far to the west–forming Ivory Coast tektite field.	6.5 N	1.4 W
20*	Monturaqui (Chile)	<1 Ma	Shock-melted impactite, containing Ni-Fe spherules from the impacting meteorite, is found here.	23.9 S	68.3 W
21*	Río Cuarto (Argentina)	<0.1 Ma	Southernmost crater, and elliptical; only known crater formed by stony, rather than far less common iron, meteorite.	32.9 S	64.2 W
22*	Lonar (India)	0.052 ± 0.006 Ma	Well-preserved crater formed in basalt lava surface; affords unique comparisons with craters in similar lunar lavas.	20.0 N	76.5 E
23	Barringer (Meteor)(Arizona, USA)	0.049 ± 0.003 Ma	"Textbook" crater (see Inset VI)–the first recognized as caused by meteorite impact–was used in astronaut training.	35.0 N	111.0 W
24*	Haviland (Kansas, USA)	<0.001 Ma	Unusual meteorites found near a 15 m-wide buffalo wallow, shown to be an impact crater by excavations in 1929.	37.6 N	99.2 W
25	Sikhote Alin (Russia)	0.000055 Ma	Large meteorite shower, seen by many in 1947, left >100 small craters and >8000 meteorites over ~ 50 km^2 area.	46.1 N	134.7 E

Table 2. Notable VOLCANIC ERUPTIONS

No.	Volcano (location)	Date	Importance	Lat	Long
1	Yellowstone (Wyoming, USA)	2 Ma	Huge eruption (2500 km^3 of magma) blanketed western U.S with ash (>2 cm in California, 1500 km away; see inset V).	44.4 N	110.7 W
2	Santorini (Greece)	1640 B.C.	Bronze Age caldera-forming eruption influenced decline of Minoan civilization; tsunami may have inspired biblical flood legends.	36.4 N	25.4 E
3	Etna (Italy)	1500 B.C.	First historically documented eruption; Europe's largest volcano, Etna has been frequently active since.	37.7 N	15.0 E
4	Vesuvius (Italy)	A.D. 79	Pompeii and Herculaneum buried; earliest known written account for any eruption, by Pliny the Younger.	40.8 N	14.4 E
5	Taupo (New Zealand)	~180	16,000 km^2 (15 % of North Island) devastated; only a deceptively tranquil caldera lake now marks the eruption site.	38.8 S	176.0 E
6	Rabaul (Papua New Guinea)	540±90	Caldera- (and harbor-) forming eruption; regional volcano observatory established after 1937 eruption.	4.3 S	152.2 E
7	Ojos del Salado (Chile)	~700	World's highest active volcano, at 6,887 m; no known historical eruptions, but strong fumarolic activity.	27.1 S	68.5 W
8	Lakí-Grimsvötn (Iceland)	1783	Enormous lava flows; livestock poisoned by volcanic fluorine and 10,000 Icelanders starve; cooled Europe's climate.	64.4 N	17.3 W
9	Unzen (Japan)	1792	Japan's deadliest eruption; collapse of dome produced debris avalanche and tsunami, killing 14,500.	32.8 N	130.3 E
10	Tambora (Indonesia)	1815	Largest historical explosive eruption, resulting in ~60,000 deaths and 1816's "year without summer" (June snow in New England!).	8.3 S	118.0 E
11	Krakatau (Indonesia)	1883	Caldera collapse; 40-m-high tsunamis kill >34,000; explosions heard >4500 km away; vivid sunsets.	6.1 S	105.4 E
12	Mont. Pelée (West Indies)	1902	High-speed, incandescent pyroclastic flows kill 28,000 in minutes; response launched modern volcanology.	14.8 N	61.1 W
13	Santa María (Guatemala)	1902	5,000 killed when volcano erupts after long repose; growth of lava dome began 20 years later and continues to date.	14.8 N	91.6 W
14	Novarupta-Katmai (Alaska, USA)	1912	Largest 20th century eruption (including "Valley of Ten Thousand Smokes"); sound heard 1200 km away; climate affected globally.	58.3 N	155.2 W
15	Parícutin (Mexico)	1943	Volcano birth in cornfield witnessed by farmers; cinder cone grows to 336-m height in first year, to 424 m by 1952.	19.5 N	102.3 W
16	Surtsey (Iceland)	1963	New island formed by 4-year eruption, providing field laboratory for biologists to study arrival of flora and fauna to new land.	63.4 N	20.3 W
17	Tolbachik (Kamchatka)	1975	Eruption time and place accurately predicted (TV crews were on hand), in world's most volcanically active region.	55.8 N	160.3 E
18	Nyiragongo (Congo)	1977	Highly fluid flows from summit lava lake reached speeds of 60 km/hr; slower flows in 2002 engulfed center of Goma city.	1.5 S	29.3 E
19	Mount St. Helens (Washington, USA)	1980	Well-studied landslide, later found to be common worldwide, showed that flank collapse can trigger explosive eruptions.	46.2 N	122.2 W
20	Kilauea (Hawaii, USA)	1983	Start of ongoing rift eruption, longest-running in Hawaii since A.D. 1400; has already created ~2.2 km^2 of new land.	19.4 N	155.3 W
21	Ruiz (Colombia)	1985	Small eruption melted icecap of 5,389-m-high volcano; resulting mudflows killed >22,000, in towns >40 km from crater.	4.9 N	75.3 W
22	Oshima (Japan)	1986	Highest historical lava fountains (>1,500 m); this island south of Tokyo has erupted more than 80 times since A.D. 605.	34.7 N	139.4 E
23	Redoubt (Alaska, USA)	1989	Jumbo jet's engines all fail in ash cloud, but two were restarted 1500 m above mountains; $80 million damage to plane.	60.5 N	152.8 W
24	Pinatubo (Philippines)	1991	Evacuations save up to 20,000 lives; mudflow damage, some recurring long after eruption ended, leaves >200,000 homeless.	15.1 N	120.4 E
25	Juan de Fuca Ridge (off NW USA)	1993	First well-documented deep ocean eruption–world's most common type, but never witnessed–along divergent boundary (see inset I).	46.5 N	129.6 W

Table 3. Notable EARTHQUAKES
[M=magnitude. Magnitudes listed here are selected from technical articles on these events and may differ from published catalog values]

No.	Earthquake (location)	Date	Importance	Lat	Long
1	Shanxi (eastern China)	1556	Deadliest earthquake on record with 830,000 reported killed. Near Xian, China's ancient capital.	35.5 N	109.7 E
2	Cascadia (Pacific NW, USA)	1700	M ~9 shock; subsidence drowned local coastal forests and triggered tsunamis that damaged distant Japan.	47.6 N	125.1 W
3	Lisbon (Portugal)	1755	Offshore event that caused strong shaking, 6- to 15-m-high tsunami waves, and a fire in Lisbon that killed ~60,000.	36.5 N	11.3 W
4	New Madrid (Missouri, USA)	1811-12	Three very large shocks over a 2-month period rang church bells near Philadelphia and cracked ice in Chesapeake Bay.	36.0 N	90.0 W
5	Charleston (South Carolina, USA)	1886	Shaking felt from Bermuda to Minnesota; moderate to severe damage to masonry buildings in Charleston.	32.9 N	80.1 W
6	Nobi (Japan)	1891	Ground ruptures showed that movements along faults caused this M 8 earthquake. First modern aftershock study.	35.4 N	136.8 E
7	Assam (northeastern India)	1897	M >8 earthquake in Himalaya collision belt; Earth's liquid iron core deduced from its seismograms.	26.0 N	91.0 E
8	North Shikoku Basin (Japan)	1906	Earliest well-documented deep earthquake (340 km), showing that earthquakes can occur in Earth's deep mantle.	34.0 N	138.0 E
9	San Francisco (California, USA)	1906	M 7.8 shock on San Andreas fault; fire destroyed much of city (see inset VII). Stimulated earthquake science and elastic-rebound theory.	37.8 N	122.5 W
10	Messina (Italy)	1908	~85,000 dead from widespread effects of ground shaking, slope failures, fire, and a tsunami in the Strait of Messina.	38.0 N	15.5 E
11	Zagreb (Croatia)	1909	Mohorovičić discovered a jump in seismic-wave speeds, generally marking the crust-mantle boundary (the Moho).	45.5 N	16.1 E
12	Gansu Province (China)	1920	M 8.3-8.6 earthquake in the broad India-Eurasia collision belt. Widespread damage and ~200,000 deaths.	36.6 N	105.3 E
13	Kanto (south of Tokyo, Japan)	1923	M 7.9 subduction shock killed 146,000 (99,000 in Tokyo), including losses from a tsunami and giant firestorm.	35.4 N	139.1 E
14	West Nelson (New Zealand)	1929	Earth's solid inner core, inside the liquid outer core. revealed in its seismic records (by Inge Lehmann in 1936).	41.8 S	172.2 E
15	Chillán (southern Chile)	1939	Occurred at 80-km depth within the subducting Nazca slab, causing 28,000 deaths; led to improved building codes in Chile.	36.2 S	72.2 W
16	Unimak Island (Alaska, USA)	1946	M 8.5 shock triggered submarine landslide, generating tsunami with run-up to 31 m on nearby Unimak Island and 18 m in Hawaii.	53.3 N	163.0 W
17	Offshore Kamchatka (Russia)	1952	Seismograms of this well-recorded M 9 earthquake showed early evidence of slow, whole-earth vibrations.	52.8 N	159.5 E
18	Adreanof Islands (Alaska, USA)	1957	At M 9.1, second of only five earthquakes in the magnitude 9 range, all in a 12-year period, since global recording began around 1895.	51.3 N	175.8 W
19	Valdivia (southern Chile)	1960	Largest earthquake (M 9.5) yet recorded, confirming whole-earth vibrations; triggered a giant Pacific-wide tsunami.	38.2 S	72.6 W
20	Southern Alaska (USA)	1964	Second largest recorded earthquake (M 9.2) caused extensive soil failure in Anchorage area and widespread tsunami damage.	61.1 N	147.6 W
21	Offshore northern Peru	1970	Within Nazca slab at 73-km depth, killing ~54,000, including 25,000 at Yungay, a town buried by an associated rock avalanche.	9.2 S	78.8 W
22	Tangshan (China)	1976	Devastated the city, causing the most fatalities for a 20th century earthquake estimates range from 255,000 (official) to 655,000.	39.5 N	117.9 E
23	Northridge (California, USA)	1994	Rocked the Los Angeles basin; economic loss estimated to exceed $20 billion, a record for U.S earthquakes.	34.2 N	118.5 W
24	Northwestern Bolivia	1994	Deepest large-magnitude earthquake (M 8.3 at 636 km); shaking felt to Canada; whole-earth vibrations further refined Earth's structure.	13.8 S	67.6 W
25	Kobe (Japan)	1995	Major port city devastated: 5500 dead, 310,000 homeless, and world record $150 billion in earthquake and fire losses.	34.6 N	135.0 E
26	Sumatra-Andaman (Indonesia)	2004	M 9.0+ earthquake ruptures >1000 km of subduction boundary; tsunamis kill a record >230,000, some deaths as distant as Africa.	3.3 N	96.0 E

Table 4. Notable PLATE TECTONICS MILESTONES [Table not included on published map]
This 400-yr history represents just 0.001 mm measured (0.000004 inch) at the same scale as the 550-million-year geological timeline at the bottom of the back of the map.

No.	Scientist(s)	Date	Importance
1	Abraham Ortelius (Holland)	1596	Recognized the close geometrical fit of E & W Atlantic shorelines, suggesting separation of continents over time.
2	James Hutton (Scotland)	1785	Key idea in geology: “The present is the key to the past”; later championed by Lyell in *Principles of Geology*.
3	Matthew Maury (US)	1855	Mid-Atlantic ridge discovered by wire depth soundings; data used for telegraph cable routing.
4	Edward Suess (Austria)	1890	Similarities in land fossils of southern continents suggest they were once joined as a supercontinent (Gondwanaland).
5	Bernard Brunhes (France)	1906	Earth's magnetism, recorded in rock minerals, shows rapid switching of north and south poles in geologic past
6	Alfred Wegener (Germany)	1915-29	Advanced bold but controversial continental drift theory in four editions of *Origin of Continents and Oceans*.
7	Arthur Holmes (UK)	1928	Proposed mantle convection drives continental drift and mountain building; elaborated in 1930s by David Griggs
8	Kiyoo Wadati (Japan)	1935	Inclined seismic zones are first mapped, under Japan; discussion of their origin anticipates the subduction concept.
9	Maurice Ewing and Bruce Heezen (USA)	1947-54	Seafloor sediments thicken with distance from Mid-Atlantic Ridge, suggesting bedrock ages increase similarly.
10	Bill Menard and Bob Dietz (USA)	1952	Fracture zones first mapped on seafloor; now known to be inactive transform faults (20) that record past plate motions.
11	Marie Tharp, Bruce Heezen, and Maurice Ewing (USA)	1953-61	A median rift (tensional) valley, a central magnetic anomaly, and earthquakes characterize the Mid-Atlantic Ridge.
12	Ted Irving (Australia), Keith Runcorn (UK)	1956	Earth's former magnetic pole positions, recorded in rocks, differ among continents, but are reconciled by continental drift.
13	Ron Mason, Arthur Raff, and Victor Vacquier (USA)	1958-62	Seafloor magnetic anomalies off western US show a striped pattern and some are offset at fracture zones.
14	Harry Hess (USA), Bob Dietz (USA)	1960-62	Ocean basins open along ridges by seafloor spreading, carrying continents along (conveyor belt analogy).
15	Bob Coats, Jack Oliver, and Bryan Isacks (USA)	1961-67	Subduction process is conceived, explaining the occurrence of arc volcanoes and earthquakes along narrow zones.
16	Many scientists (mostly USA)	1961-69	New global seismic network improves accuracy of earthquake locations, helping resolve and define plate boundaries.
17	Tuzo Wilson (Canada)	1963a	Hotspot concept explains trends of intraplate volcanic island chains; helps track past plate motions.
18	Allan Cox, Richard Doell, Brent Dalrymple (USA)	1963b	Time scale of magnetic polarity reversals (5) is derived from radiometric ages of magnetized rocks.
19	Fred Vine & Drum Matthews (UK), Larry Morley (Canada)	1963c	Magnetic stripes (13) record magnetic polarity reversals (18) during spreading (conveyor belt is also a tape recorder).
20	Tuzo Wilson (Canada)	1964-65	Transform faulting conceived; later confirmed from fault motions for earthquakes by Lynn Sykes
21	Lynn Sykes, Wm Stauder, Bryan Isacks, Peter Molnar (USA)	1966-72	Earthquake activity and fault motions, deduced from seismic records, reflect and help define plate motions.
22	Jason Morgan (USA), Dan McKenzie & Bob Parker (UK)	1967	Plate motions quantitatively modeled; later refined by Le Pichon, Chase, Minster & Jordan, and others.
23	International drilling programs (DSDP/ODP)	1968-on	Drilling of seafloor and dating of those rocks confirm seafloor ages predicted by the spreading model.
24	US Navy/NASA, Bill Haxby, Sandwell & Smith (USA)	1978-on	Marine gravity and seafloor relief mapped by satellite radar echoes from small-but-measurable effect on sea level.
25	NASA, Dept of Defense, and many others (USA)	1985-on	Astronomical and satellite survey methods (such as GPS) accurately measure present-day plate motions.