Emeralds of the World

Notes on known emerald occurrences
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Abbreviations:

Sim: Similar or other deposits

Finds: Quality of emerald specimens and significant finds

Beryl: Type of beryl or emerald and the chromophorous elements (as weight % of the oxides Cr_2O_3, V_2O_3 and FeO)

Geo: Geology and origin

Mat: Matrix or host rock

Incl: Solid inclusions (fluid inclusions are not noted)

Ref: References or recommended reading for further information on a deposit

ASIA

PAKISTAN • Mohmand Region

Gandao: 100 workings in a 1 km^2 area on the NW slopes of Tora-Tigga Mt. SE of Tora-Tigga village, Mohmand Region, 43 km NW of Peshawar, NW Pakistan
Finds: No commercial significance
Beryl: Green beryl, colored (at least in Gandao) by vanadium (up to 0.7%) and chromium (up to 0.1%)
Geo: Countless quartz veins and lenses in an alternating greenschist-dolomite layers with mobilization of beryllium from nearby beryl-bearing pegmatites
Mat: Quartz veins and lenses in dolomite rock
Sim: Nawe Kili (Nawe Dand), Tsapari, Bucha, Pranghar, Khanori Kot and Zankhae
Incl: Quartz, dolomite, tremolite, talc, chlorite, epidote and phlogopite
Ref: For Pakistan, Afghanistan and India: Kazmi and Snee (1989)

PAKISTAN • Swat District

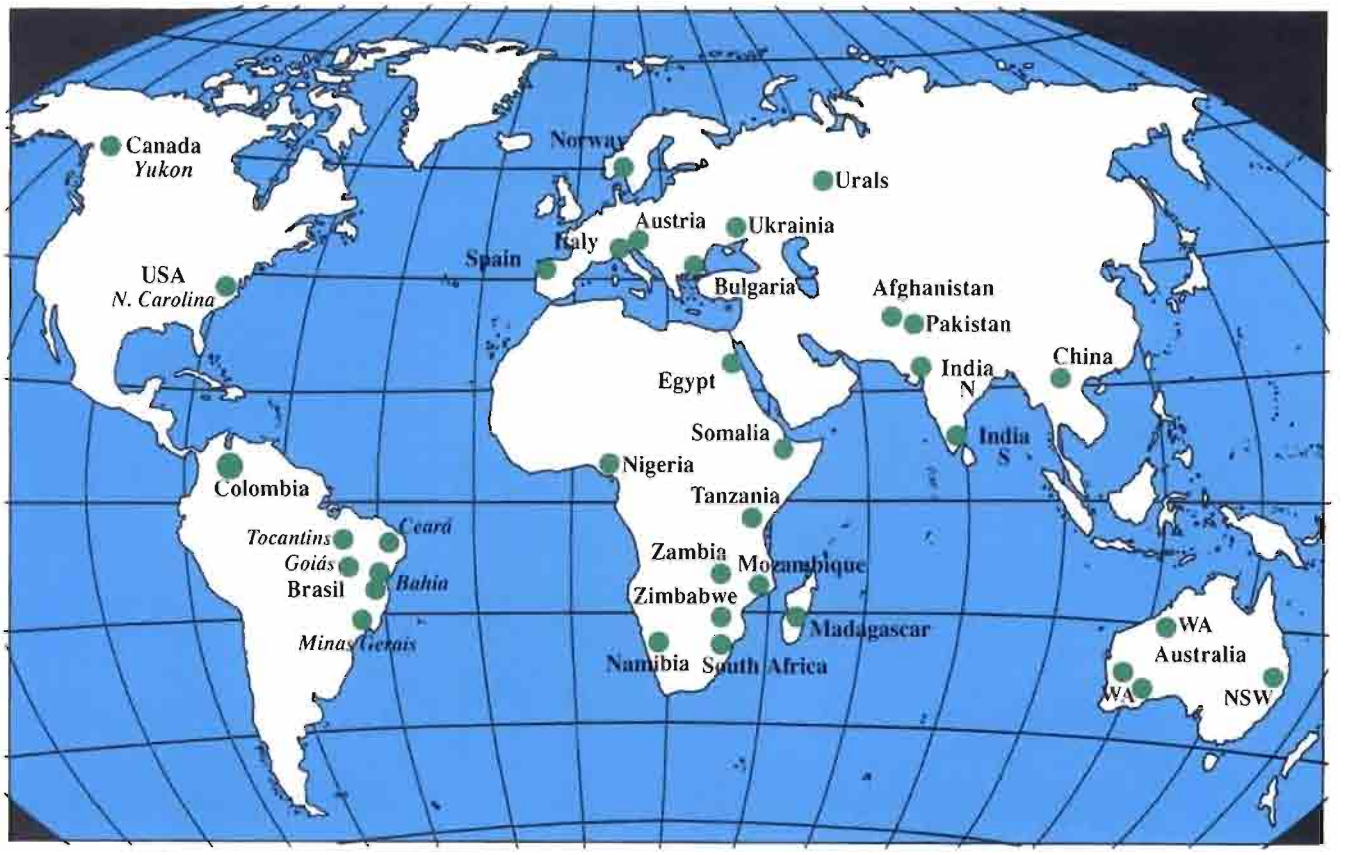
Mingora Mine, in the Swat River Valley, 200 km NE of Peshawar. Largest deposit in Pakistan: discovered in 1958. Five mines, Mine 1 (Farooq Mine), Mine 2, Mine 3, Islamia Trench, Carrel's Trench, spreading SSW to NNE over 1 km
Finds: Richest deposit in Pakistan with the best quality finds. Emeralds easily detach from matrix; matrix specimens rare; crystals 1 to 2 cm, rarely up to 10 cm
Beryl: Colored by chromium and iron; color always inhomogeneous, often sharply zoned; high magnesium contents (up to 3% MgO)
Geo: Sporadic emerald mineralization in talc-carbonate schist related to fault zones in the Charbagh greenschist zone or Mingora ophiolite zone; beryllium introduced by hydrothermal fluids of magmatic or regional metamorphic origin
Mat: Magnesite-talc-quartz schist, talc-chlorite-dolomite schist and chlorite schist, quartz lenses, magnesite-siderite-calcite-quartz rocks; country rock is carbonate-bearing metapelite and graphite schist
Sim: Gujarkili, Chabargh, Makhad, Alpurai, Malam, Bar Kotkai, Bazarkot, also Khazana (Shamozai Region) discovered early 1990's
Incl: Actinolite, fuchsite, chromite, chromium-dravite, enstatite, plagioclase, tourmaline, gersdorffite, magnesite, dolomite, pyrrhotite, chlorite and quartz
Ref: Arif et al (1996)

PAKISTAN • Bajaur Region

Barang-Turghao (Mor-Darra): 80 km N of Peshawar in the Bajaur region
Finds: No commercial significance
Beryl: Colored by chromium and iron
Geo: Contact metasomatism between ultrabasic and quartz-feldspar rocks
Mat: Quartz-calcite-feldspar veins in talc schist at contact with amphibole-chlorite-talc schist and talc-carbonate rocks
Sim: Amankot, Maimola, Nawe Dand: south of Nawe Dand village, 40 km N of Peshawar, Bajaur region
Incl: Quartz, plagioclase, calcite, phlogopite, talc, chlorite, actinolite

PAKISTAN • Gilgit Division

Khaltaro deposits: known as *Rayjut* near Khaltaro, Haramosh Range, 70 km E of Gilgit, northern Pakistan; discovered 1985, rugged terrain at 4,100 m in the Nanga Parbat-Haramosh massif
Finds: Inclusion-rich and fractured emeralds, rarely gem quality; rough stones 1 to 3 cm diameter
Beryl: Colored pale to medium green by chromium and iron
Geo: The only deposit in Pakistan with contact metasomatism between amphibolite and crosscutting fluorine-rich pegmatitic hydrothermal vein system, situated near the northern border of the Indian tectonic plate
Mat: Medium- to coarse-grained biotite-muscovite-albite-quartz-tourmaline-fluorite zones in miarolitic pegmatite
Incl: Quartz, biotite, white mica, plagioclase, tourmaline, fluorite
Ref: Laurs et al (1996)



The World of Emeralds in 2002

AFGHANISTAN • Konar Province

Badel Mine near Badel, Konar Province, NE Afghanistan

Finds: Crystals inclusion-rich, fractured; gem quality rare

Beryl: Grass green, often milky clouded

Geo: 20 m long, 20-50 cm wide pegmatite dikes in amphibolites with metasomatic contact zones of phlogopite schist

Mat: Phlogopite schist

Incl: Phlogopite, quartz, feldspar

Ref: Rossovskiy (1980)

AFGHANISTAN • Laghman Province

Lamonda and Korgun Mines, Laghman Province, NE Afghanistan

Finds: Small quantities; gem quality rare

Beryl: Moderate green, cracked or lightly included

Geo: Probably pegmatite dikes

Lit: Laurs (2001)

AFGHANISTAN • Panjshir Valley

Buzmal, Khenj and Mikeni Mines in the Panjshir Valley, Parwan province; deposits SE of the Panjshir River perhaps known already in Pliny's time as the *smaragdus* from Bactria (present day Iran and Afghanistan); the deposits stretch NE-SW from Aryu, past Deste-Rewat and Mikeni, as far as Khenj, over an area of 400 km^2, elevation 2,100 to 4,300 m; Khenj in the Kapisa district, Parwan Province, 110 km from Kabul

Finds: The best material came from the Mikeni and Khenj mines; crystals to 5 ct, gem quality over 10 ct rare, but exceptionally to 15 ct

Beryl: Saturated green color from chromium

Geo: Regional metamorphic-metasomatic; beryllium-rich hydrothermal fluids reacted with muscovite schists

Mat: Alternating metasediments and meta-gabbros in an upper greenschist facies cut by quartz-ankerite veins or silicified zones of phlogopite, albite, tourmaline and pyrite

Sim: Sahpetaw, Butak, Abal, Takatsang, Sakhulo, Pghanda, Qalat, Zarakhel, Derik, Buzmal, Yakhnaw, Shoboki, Darun Rewat (incl. Riwat, Dahane Revat) and Puzughur

Incl: Albite, phlogopite, goethite, pyrite, quartz and carbonate

Ref: Bowersox et al (1991); Sabot et al (2000); Vapnik & Moroz (2001)

N. INDIA • Bubani, Rajhastan

Bubani Mine in the Rajhastan emerald belt (stretches over 200 km SW-NE between the cities of Ajmer and Udaipur in Rajhastan Province)

Finds: First finds in modern times, 1943; overwhelmingly low to medium quality stones with good color, purity rare; the best Indian emeralds are from the Rajghar deposit

Beryl: Pale green to deep green porphyroblasts colored by chromium

Geo: The series (phyllites) of the Delhi System is cut by numerous tourmaline-granites and pegmatites; emerald-bearing veins are at the metasomatic contact between the pegmatites and talc schist

Mat: Phlogopite schist, actinolite schist, talc schist and quartz-feldspar-muscovite-tourmaline rocks

Sim: First production area: Ajmer-Merwara with Chat, Rajghar and Bithur; second area: Mewar with Tekhi (Tikki),

Kaliguman, Gaongurha (Gum Gurha)
Incl: Muscovite, biotite, phlogopite, talc, quartz, feldspar, actinolite, apatite, tourmaline and calcite
Ref: Roy (1955); Kala (1978)

S. INDIA • Sankari Taluka

Sankari Taluka, Salem district, Tamil Nadu and southern India; the first emeralds were discovered in early 1995 on the inner wall of a water well

CHINA: *An emerald specimen from the Malipo region (field of view 14 cm). Yunnan, M. Herrmanns collection; Stefan Weiss photo*

Finds: Gem quality rare and small; crystal size 2-3 cm
Beryl: Colored by chromium and iron; rich in inclusions; healed fractures parallel to the c-axis; wavy inclusion trails in finely folded matrix
Geo: Element exchange by regional metamorphism between ultrabasic and quartz-feldspar rocks
Mat: Phlogopite, chlorite, actinolite and talc schists
Sim: Near Idappadi and Konganapuram villages
Incl: Phlogopite, apatite, quartz, chlorite, feldspar, amphibole, pyrite, tourmaline and spinel
Ref: Panjikar et al (1997)

CHINA • Malipo, Yunnan

Malipo County, Ailaoshan region: emerald deposits discovered in early 1980's (?); numerous mines spread over an unknown area
Finds: Because of the noteworthy quality of large matrix specimens with fence-like or radiating aggregates of emerald crystals, we can assume these deposits to be important producers, but production is unknown; crystals to 6 cm, occasionally 15 cm long and up to 2 cm in diameter
Beryl: Emerald in gneiss and pegmatite; colors from vanadium (0.21%), chromium (0.19%) and iron (0.43%) according to type of matrix: yellow-green in pegmatite and tourmalinite, bluish green in mica schist and banded gneiss
Geo: Unknown
Mat: **Type a**) coarse-grained to giant-grained metapegmatites next to fine-grained fibrous tourmalinites; **type b**) albitized, fluorite-bearing, sulfide-rich banded biotite-gneiss with quartz and calcite lenses and feldspar wallrock
Incl: Biotite, phlogopite, quartz, plagioclase, K-feldspar, calcite, muscovite, phengite, fluorite, apatite, tourmaline, arsenopyrite, pyrite, chalcopyrite, pyrrhotite and pentlandite
Ref: Zhang et al (1999)

Australia

WA • Poona Village

A 10 km^2 area of land around Poona village, 65 km NW of Cue in the Murchison Range; first open pit 1912, *Reward Claim ML 45*; further workings: Aga Khan Open Cut, Aga Khan Deep Mine, Quartz Blow Open Cut, Solomon Open Cut, Mid Section, Reward Open Cut, Lee's Trench and Catherine's Trench
Finds: Most productive emerald deposit in Australia, discovered early in the 20th century by tin prospectors; emeralds are rich in inclusions and often fractured; cuttable stones rare in spite of the saturated green color; crystals up to 4 cm, exceptionally to 15 x 4 cm
Beryl: Pale green to green porphyroblasts colored by chromium and iron, partly zoned with increasing color intensity from core to edge
Geo: On the southern border of the Weld Range greenstone belt in the center of the Murchison Province, NW Yilgarn Craton, developed 3 to 2.6 billion years ago; the lenticular or vein-like emerald-bearing phlogopite schist is interpreted to have been the product of regional metamorphism between the pre-metamorphism pegmatite, muscovite-aplite, quartz-topaz-greisen and ultrabasic rocks
Mat: Phlogopite schist, margarite-topaz-phlogopite schist, alexandrite-corundum-topaz-fluorite-phlogopite rocks, phlogopite-actinolite schist
Sim: Poona East Emerald Mine, Emerald Pool Mine (The Gem Mine), Warda Warra near Yalgoo (75 km WSW of Cue), Melville (Noongal) in Yalgoo Goldfield (130 km SW of Poona)
Incl: phlogopite, actinolite, muscovite, zinnwaldite, margarite, fluorite, topaz, chrysoberyl, quartz, zircon, monazite, cassiterite, scheelite, apatite, chlorite, epidote, albite, K-feldspar, tantalite, ferrocolumbite and chromite
Ref: Grundmann & Morteani (1998); Darragh & Hill (1983)

WA • Menzies

50 km W of Menzies on Riverina Station, discovered by geologists in 1974
Finds: Gem quality rare, small crystals up to 2 cm long, mostly rich in inclusions; fractures healed by quartz
Beryl: Emerald porphyroblasts, green, yellow-green to blue-green from

POONA, WA: View of the phlogopite schist zone with emerald-feldspar lenses in the Aga Khan Mine. Günter Grundmann photo

EMMAVILLE, NSW: A 16 mm long emerald in quartz. W. Schäfer coll.

chromium and iron
Geo: A 500 x 120 m ultrabasic body in the Norseman-Wiluna nickel sulfide belt (Yilgarn craton) reacted with pegmatite to form emerald-bearing phlogopite schists at the border of serpentinites
Mat: Phlogopite schist, talc-chlorite schist, quartz-feldspar and dolomite-quartz rocks
Incl: Quartz, phlogopite, actinolite, chromite, chlorite, albite and dolomite
Ref: Whitfield (1975)

WA • Wodgina

113 km south of Port Hedland in northern Western Australia, the locality is about 3 km NW of Wodgina
Finds: Famous area for cesium-beryl, tantalite and wodginite; produced over 1,000 tons of beryllium ore; limited occurrence of small gem-quality emeralds
Beryl: Prismatic crystals colored pale green by chromium and iron
Geo: Folded metasediments and greenschists with pegmatite intrusions in the Pilbara craton; emerald-bearing series within metasomatic contact zones
Mat: Phlogopite, chlorite and talc-schist, quartz-feldspar rocks
Sim: Pilgangoora, 80 km SSE of Port Hedland; Calvert White Quartz Hill, 180 km SE of Port Hedland; McPhee's Patch Emeralds, Curlew Mine, 19 km NW of Hillside Station
Incl: Quartz, albite, chlorite, phlogopite, apatite and tantalite
Ref: Schwarz (1991)

NSW • Emmaville

The mine is 9 km NNE of Emmaville (Vegetable Creek), 5 km SW of Torrington in northern New South Wales
Finds: Australia's first emerald occurrence, discovered in 1890; radiating aggregates of hexagonal prisms up to 3 cm long; gem quality rare; matrix specimens very rare
Beryl: Yellow-green color caused by combination of low amounts of chromium (up to 0.15%), vanadium (0.08 to 0.16%) and iron (0.13 to 0.25%); extremely low magnesium and sodium contents, spectacular multiple zoning parallel to the base (in Torrington)
Geo: Permian, metamorphically overprinted series of clays, siltstones and quartzites, cut by aplites and pegmatites of the neighboring Mole granite pluton; emeralds in greisen dikes of quartz, topaz, feldspar and mica partly in vugs
Mat: Fluorite-quartz-topaz-beryl veins with subordinate cassiterite and arseno-pyrite
Sim: Torrington, discovered early 1890 about 20 km E of Emmaville
Incl: Fluorite, quartz, cassiterite and arsenopyrite
Ref: Brown (1984); Schwarz (1991)

Africa

EGYPT • Eastern Desert

Sikait, SW of Marsa 'Alam, Eastern Desert Region
Finds: One of the oldest gemstone producers in the world; first provable finds in the Ptolemaic era (about 323 B.C.); source of most emeralds in Roman jewelry; crystals up to 2 cm, rarely over 5 cm; collector's specimens rare
Beryl: Colored by chromium and iron; generally clouded by fractures and fluid inclusions
Geo: Metasomatic exchange between meta-aplites, meta-pegmatites and ultrabasic rocks (talc schists)
Mat: Phlogopite, chlorite and talc schist, quartz-carbonate-feldspar rock
Sim: From NW to SE, Gebel Zabara (Gabal az-Zabari) through Gebel Sikait (Jabal Sakit) as far as Gebel Umm Kabo (Jabal Umm Kabu), thousands of open pits and underground workings
Incl: Phlogopite, quartz, plagioclase, white mica, talc, carbonates, actinolite, chlorite, epidote, apatite and ilmenorutile
Ref: Basta & Zaki (1961); Grundmann & Morteani (1993); Abdalla & Mohamed (1999)

MADAGASCAR • Mananjary

South zone: Morafeno, Ambodibonary, Ambatomameno; north zone: Ambodibakoly, Mourarano Ambodivandrika, Ankeba and Tsaravolo
Finds: Significant mines on the east coast, known since Lacroix 1913; crystals in open pit mine to 1 kg, rarely gem quality; good collector specimens, e.g. a 1989 find weighing 76 kg, measuring 64 x 45 x 23 cm with 127 emeralds in phlogopite matrix; the largest is 11.5 x 5.5 x 3.5 cm
Beryl: Porphyroblasts colored by chromium and iron, heavily included
Geo: Pegmatite dikes in Precambrian volcano-sedimentary series; metasomatic exchange between pegmatites, metabasites and ultrabasics of the Pan-African orogeny (490 million years ago)
Mat: Phlogopite, tremolite, chlorite and talc schist; tourmaline and quartz veins and feldspar
Sim: Tulear province; Irondro, Ifanadiana (alluvial), Ambodirofia, Mohotsani II, Ambilanifitorana and Ambodizainana. Ianapera: no pegmatites; metamorphic fluids flow in shear zone cutting volcano-sedimentary series
Incl: Phlogopite, white mica, actinolite, tourmaline, chlorite, apatite, hematite, pyrite, quartz, ilmenite, K-feldspar, plagioclase, carbonates, talc, molybdenite, wolframite, fluorite, barite and spinel
Ref: Schwarz et al (1994); Petsch & Kanis (1998); Cheilletz et al (2001)

MOZAMBIQUE • Morrua

The Maria mines in the Morrua district between Morrua (W), Gile (N) and Mualama (S); first reliable reports early 1970's; ensuing production in Maria I, II and III (Rio Maria III)
Finds: Questionable reports of finds of stones over 1,000 ct weight; maximum production 1993/94 with about 130 kg rough stones
Beryl: Pale blue-green to green emeralds colored by chromium and iron
Geo: Quartz veins cut through an alternating series of Precambrian metabasites (amphibolites) and ultrabasics (serpentinites); contact zone of phlogopite, actinolite and talc schists
Mat: Phlogopite schist, plagioclase-muscovite-quartz lenses
Sim: Niame emeralds near Gile, Meleia emeralds north of Muamala, Cabral Mine, Meleia
Incl: Quartz, phlogopite, albite, muscovite, scheelite, apatite, molybdenite, pyrite, fluorite, calcite and talc
Ref: Neves (1978); Tomas (1994)

EGYPT: Zabara, one of "Cleopatra's mines," on the NW slope of the deposit; photo taken in 1992 by Günter Grundmann

NAMIBIA • Malta Heights

Neuhof 100 farm, Malta Heights district
Finds: Discovered in 1992; small, limited occurrence; crystals of attractive color and good cutting quality very rare; fractured by deformation, rich in inclusions, milky
Beryl: Pale green beryl and emerald colored by chromium
Geo: Regional metamorphic overprinted amazonite-pegmatite bodies in contact with greenschists, amphibolites and ultrabasics with contact zones of phlogopite, chlorite, tremolite and talc schist; dominant country rocks are orthogneiss and garnet-amphibolite
Mat: Phlogopite schist, quartz-feldspar lenses mostly strong boudinized
Sim: A few km SE of Usakos, on Narubis 67 farm; Hammerstein farm, 10 km straight from Neuhof
Incl: Phlogopite, light mica, chlorite, quartz, actinolite, fluorite and gadolinite
Ref: Kling & Schäfer (2001), pers. comm.

NIGERIA • Gwantu

SE Kaduna state, central Nigeria
Finds: Good finds first reported in the early 1980's: terminated, 8 cm long crystals with prism faces
Beryl: Water-clear greenish blue to light blue crystals rich in faces, colored by iron (up to 1.13%), chromium (to 0.21%) and vanadium (to 0.09%)
Geo: Hydrothermal alteration of basement pegmatites; emerald formation by albitization of pegmatites during alkali metasomatism at 400-450° C
Mat: Microcline-albite-biotite-muscovite-quartz pegmatites with decimeter-sized miarolitic cavities with gem mineralization of beryl, emerald, topaz and tourmaline
Sim: Timber Creek near Rukuba; Barakin William in the Sha Kaleri complex; in the Janta area E of the Afu complex, 35 km SSW of Keffi
Incl: fluorite, albite, tourmaline, K-feldspar, phlogopite, ilmenite, quartz, monazite, ralstonite and boldyrevite
Ref: Schwarz et al (1996); Vapnik & Moroz (2000)

SOUTH AFRICA • Gravelotte

Leydsdorp district, Transvaal
Finds: South Africa's largest deposit; first finds as early as 1890; large open pits and underground workings; crystals average to 3 cm, with good gem

quality; collector specimens rare
Beryl: Emerald porphyroblasts colored by chromium and iron; inclusion rich
Geo: Metasomatic exchange between pegmatites, plagioclasites and ultrabasics
Mat: Phlogopite, actinolite and talc schist, quartz-feldspar rock
Sim: Cobra, BVB and Somerset mines
Incl: Phlogopite, white mica, apatite, quartz, ilmenite, tourmaline, K-feldspar, plagioclase, carbonates, fluorite, pyrite, actinolite, talc, molybdenite, phenakite, scheelite and bismuth
Ref: Grundmann & Morteani (1989)

TANZANIA • Mayoka

Mayoka emerald and alexandrite deposit, 3 km W of shore of Lake Manyara, S of the Maji Moto hot springs, Mbulu district
Finds: Tanzania's largest deposit; exceptional parageneses; first finds 1969 in alluvial placers; production since 1970; crystals to 2 cm, good gem quality in part; matrix specimens very rare
Beryl: Porphyroblasts colored pale blue-green to yellow-green by chromium and iron, relatively gemmy
Geo: Tectonic-metamorphic influence (450 to 200 million years ago) on an alternating series of metasediments, kyanite-almandine-amphibole gneiss, granite gneiss and ultrabasics of the Mozambique belt amphibolite facies; black wall zones formed in the pressure shadow of fractures and folds
Mat: Medium- to coarse-grained amphibole-garnet-plagioclase-quartz-biotite felsites, locally associated with alexandrite, ruby, blue corundum, apatite, spinel, olivine, clinopyroxene, phenakite, tourmaline and chondrodite
Sim: Near Sumbawanga in SW Tanzania (discovered early 1988), Mangola near Endamangha
Incl: Phlogopite, amphibole, plagioclase, apatite, quartz and rutile
Ref: Bank & Gübelin (1976); Keller (1988)

ZAMBIA • Ndola Rural

Kamakanga Mine Group, 30 km SW of Kitwe, 30 km W of Luanshya in the Miku River Valley, northern Zambia
Finds: Present producer of emeralds; excellent crystals up to 20 ct
Beryl: Pale green to green, colored by chromium (to 1.6%) and iron (to 1.8%)
Geo: In the rocks of the De-Muva group (1 to 1.4 billion years old), metasomatic exchange between magnetite-talc-chlorite-amphibole-schists and pegmatites or tourmalinites interpreted as hydrothermal veins from metamorphosed basement granites
Mat: Phlogopite schist, quartz-mica schist, tourmaline-quartz lenses
Sim: Within a radius of 12 km SE of Miku: Kafubu, Nkabashila, Mitando, Pirala, Fwaya-Fwaya, Libwente, Dabwisa, Fibolele and Chama
Incl: Biotite, chlorite, tourmaline, magnetite, talc, actinolite, quartz, calcite, dolomite and rutile
Ref: Bank (1974); Mumba & Barot (1998)

ZIMBABWE • Sandawana

65 km south of Mberengwa village in southern Zimbabwe
Finds: First finds in 1956 on the Vulcan Claim in the Belingwe district; Machingwe deposits discovered in 1987; cuttable stones average 2-8 mm; largest stone 1.021 ct; collector specimens very rare; at one time the most important emerald district in Africa
Beryl: Porphyroblasts colored by chromium (0.6 to 1.33%) and iron (0.45 to 0.82%)
Geo: Emerald formed along the Mweza greenstone belt on the southern boundary of the Archean Zimbabwe craton during folding, shearing and regional metamorphism at the contact between deformed albitized pegmatites and volcano-sedimentary rocks
Mat: Actinolite-phlogopite schists, in part with cummingtonite, holmquistite, fluorapatite, phenakite, chromium-ilmenorutile and chromite
Sim: Juno, Zeus, Ares, Eros, Orpheus
Incl: Tremolite, phlogopite, carbonates, cummingtonite, apatite, albite and zircon
Ref: Kanis et al (1991); Zwaan et al (1997); Zwaan & Touret (2000)

SOMALIA • Boorama

Small-scale diggings near Boorama, 215 km W of the coastal city of Berbera in the far NW of the country
Finds: First reports came in 1999 but are still unverified
Geo: Emerald-bearing zones in phlogopite schists at the contact between serpentinites and younger pegmatites of the Mozambique belt
Mat: Phlogopite schist
Beryl: Color from chromium and iron
Incl: Phlogopite
Ref: Kinnaird (1999)

EUROPE

BULGARIA • Rila, Rhodope Mts.

Rila and Rhodope Mountains; Urdini Lake in south-central Bulgaria Mountains, discovered in 1985
Finds: No mining; deposit is in a protected area; emeralds up to 6 cm, milky translucent, fractured; collector specimens marketed sporadically
Beryl: Rarely emerald green; usually colored pale blue-green by chromium (0.1%) and iron (0.1%); long prismatic crystals and radiating aggregates
Geo: A series of gneiss, amphibolite and marble in the Damga massif; zoned pegmatites to 20 m long and 2.5 m wide intruding biotite gneiss and ultrabasics at 34 million years ago
Mat: Oligoclase-phlogopite zone, quartz-feldspar lenses and phlogopite schist
Sim: Jugovo in the central Rhodope
Incl: Beryl, quartz, plagioclase, phlogopite, muscovite, apatite, zircon, magnetite, garnet, allanite, columbite, rutile, epidote, fuchsite, pyrite, chalcopyrite and calcite
Ref: Petrusenko et al (1966); Alexandrov et al (2001)

ITALY • Val Vigezzo

Near Domodossola on Pizzo Marcio, Lepontine Alps
Finds: Discovered in 1975 by collectors; crystals to 5 cm, frozen in feldspar and biotite matrix; mostly milky-turbid because of inclusions and fractures
Beryl: Colored pale green by iron, chromium and vanadium
Geo: Metapegmatites in mica schists, gneiss and amphibolite of the Insubrian crystalline basement, with locally mylonitized ultrabasic intrusions, metamorphically altered during the alpine orogeny; beryl sprouts occur at

the contact between metapegmatites and ultrabasics
Mat: Albitized pegmatites with a contact zone of phlogopite and white micas
Sim: Stream bed by train station and village border at Gagnone Orcesco, Alpe Rosso
Incl: Phlogopite, tourmaline, xenotime, columbite, monazite, albite, phengite, quartz, apatite and zircon
Ref: Albertini (1996)

AUSTRIA • Habachtal

Pinzgau, state of Salzburg: the locality is in the Leckbachgraben between the Habach and Hollersbach Valleys
Finds: Largest emerald deposit in the Alps; locally worked since 1865 by adits at four levels; described in 1797 by K. M. Schroll; stories of earlier finds are uncorroborated; crystals heavily included and fractured; gem quality finds are rare and small; beautiful collector specimens are found; crystals up to 3 cm, in exceptional cases 2 x 10 cm
Beryl: Emerald porphyroblasts, colored by chromium and iron
Geo: Paleozoic Habach Formation in the Penninic rocks of the Tauern window; regional metamorphism, metasomatic horizon-bound, at the contact between a volcano-sedimentary series and serpentinites; emeralds crystallized 25-40 million years ago
Mat: Phlogopite, chlorite, actinolite and talc schist; rarely also quartz lenses
Sim: Kesselscharte and Kesselklamm in the Untersulzbach Valley, Schneegrube, Hollersbach Valley, Felbertal scheelite deposit, Westfeld
Incl: Phlogopite, white mica, chlorite, epidote, quartz, plagioclase, K-feldspar, rutile, tourmaline, apatite, talc, actinolite, phenakite, ilmenite, pyrite, scheelite and molybdenite
Ref: Grundmann (1985; 1991); Grundmann & Morteani (1989)

Bulgaria *(upper left): 5 cm emerald in granular feldspar from Lake Urdini in the Rila mountains. Munich Technical University*

Italy *(lower left): emeralds in albitized pegmatite. Claudio Albertini collection; Roberto Appiani photo*

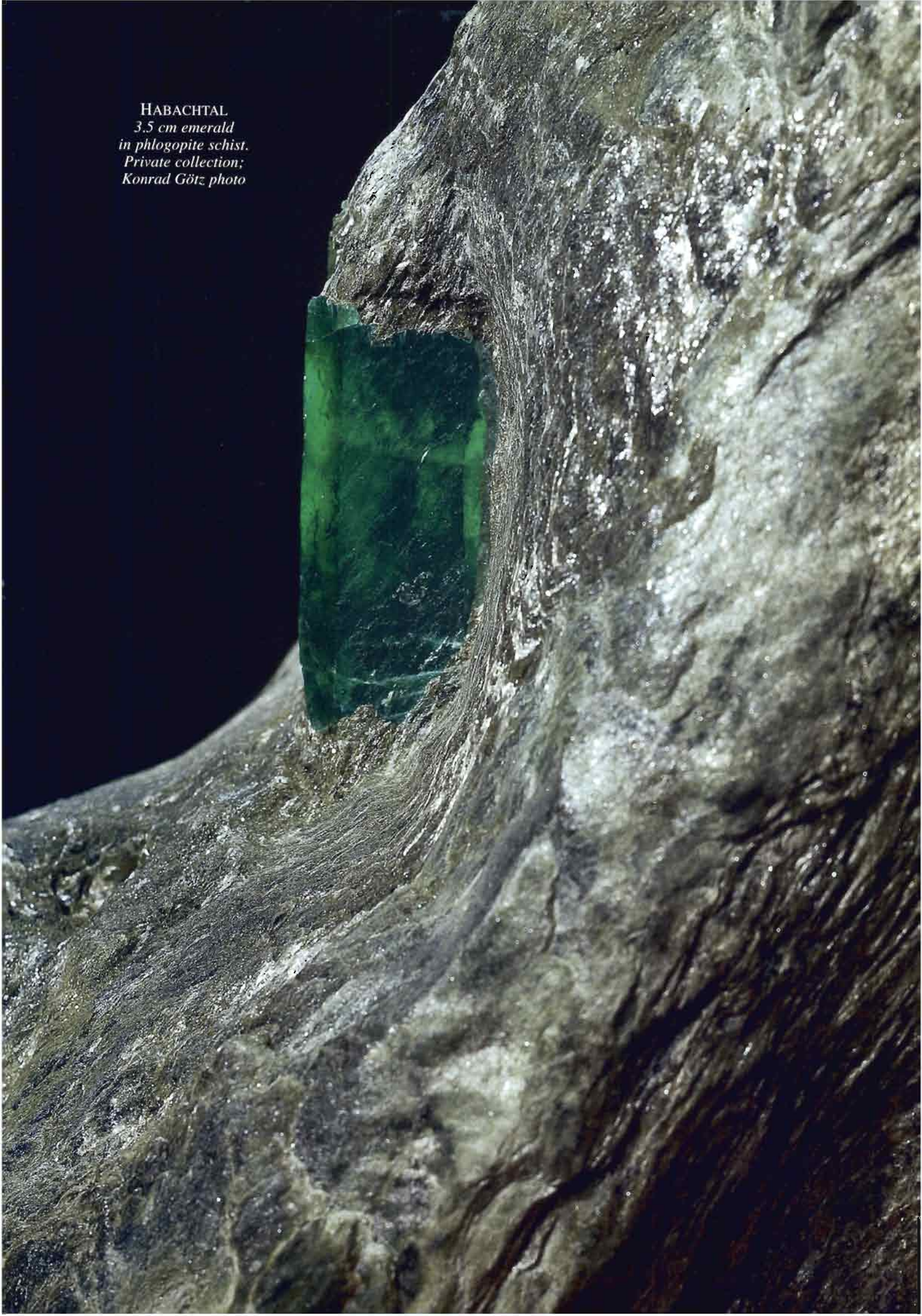
Norway *(right): 5 cm emerald from Snarum/Eidsvoll. Natural History Museum of Humboldt University in Berlin; Photo by H. Nier*

NORWAY • Eidsvoll

Byrud Gård Emerald Mine - 50 km N of Oslo, on the western shore of Lake Mjsa near Eidsvoll (near Snarum), Akerhus Province in southern Norway
Finds: First mentioned by Websky in 1876; first workings around 1880; maximum crystal size is only a few cm, translucent to opaque; inclusion free stones are very rare
Beryl: Colored green by the presence of vanadium (0.9 to 1.5%), iron (0.2 to 1.8%) and chromium (0.1 to 0.3%)
Geo: Flat-lying nordmarkite-pegmatite dikes in alum-schists and maenaite intrusions (syenite dikes) are the beryllium suppliers; alum schists supply the vanadium-iron-chromium; contact metamorphically altered
Mat: Feldspar-white mica-quartz-fluorite-pegmatoids
Incl: Feldspar, white mica, quartz, fluorite, pyrite and pyrrhotite
Ref: Sinkankas (1981)

SPAIN • Franqueira

Central Galicia, NW Spain
Finds: The only occurrence on the Iberian Peninsula; exceptional paragenesis: emerald, phenakite and alexandrite; emeralds to 10 cm long, mostly inclusion-rich, turbid; finds are scarce, collector specimens very rare
Beryl: Porphyroblasts, colored pale



HABACHTAL
3.5 cm emerald in phlogopite schist. Private collection; Konrad Götz photo

green by chromium (up to 0.16%) and iron (0.16 to 0.63%)
Geo: Contact metasomatism in an ophiolite series between pegmatite lenses; porphyroblasts in distinctly schistose country rock indicate tectonic-metamorphic alteration of the contact zone
Mat: Phlogopite schist with accessory chrysoberyl, phenakite, tourmaline, garnet, apatite and zircon
Incl: Phenakite, chrysoberyl, phlogopite, quartz, pyrite, ilmenite and anthophyllite
Ref: Martin-Izard et al (1995); Franz et al (1996); Fuertes-Fuente et al (2000)

RUSSIA • Malyshevo

Urals: Malyshevo, Takovaya (Izumrudny Kopi emerald mines): a 100 km^2 area around Takovaya stream, about 60 km NE of Ekaterinburg (Sverd-lovsk), Middle Urals
Finds: Russia's largest and oldest

emerald mining district; discovered in Tokovaya stream in 1830 by the farm laborer Maxim Koshevnikov; until the end of the 19th century, only collector specimens were dug; exports of gem rough began in 1899; by 1918, mine was the largest emerald producer in the world; 1940-1950 was the beginning of beryllium production for nuclear reactors with emeralds only as a byproduct (e.g., 1950: 3-4 million ct); exploitation of emerald, phenakite and alexandrite takes place in gigantic open pits and in underground workings to 250 m deep; drilling has proven the presence of emerald at depths up to 1,100 m; famous Kochubei emerald (11,130 ct, at the end of the 19th cent); Kommerchesky emerald (12,900 ct, found in 1982)
Beryl: In part, complex zoning; beryl crystals exhibit a colorless core which is overlain by a green outer zone colored by chromium and iron. In part green emerald porphyroblasts that grew at the expense of phenakite and/or chrysoberyl (alexandrite)
Geo: Three genesis models: **a)** Fersman (1929, 1940): desilizified granite/pegmatites at contact with ultrabasic intrusions, emerald growth in black wall zones; **b)** Beus & Dikov (1967): beryllium mineralization by topaz greisen in basic and ultrabasic rocks; **c)** Grundmann & Morteani (1989): regional metamorphic

upper
Ural, Takovaya
This emerald, a gift from Czar Nicholas to Alexander von Humboldt in 1832, is 13 cm long. Natural History Museum of Humboldt University in Berlin; photo by H. Nier

Left: a more recent find from Takovaya with a 3 cm long emerald. DeTrin collection; Jeff Scovil photo

Far left:
Spain
A 1 cm emerald crystal in phlogopite schist from Franqueira. Wolfram Schäfer collection

alteration of topaz greisen, pegmatites and aplites with pegmatitic phenakite, beryl and regional metamorphic phenakite, emerald and alexandrite
Mat: Phlogopite schists, quartz-plagioclase lenses, actinolite schist and talc schist
Sim: Seven historical mine designations (from N to S): Marinsky, Traitsky, Ljublinsky, Stretensky, Ostrovsky, Krasnobolotsky, Chitny; four presently active mines (from N to S): Malyshevo, Sverdlov, Cheremshansk and Krasnobolotny
Incl: Phlogopite, fluorite, muscovite, margarite, actinolite, talc, plagioclase, quartz, phenakite, topaz, scheelite, tourmaline, molybdenite, bavenite, bromellite, chrysoberyl, apatite and titanite
Ref: Beus (1966); Beus & Dikov (1967); Laskovenko and Zernakov (1995); Levin et al (2000)

UKRAINE • Volodarsk

Pegmatite district covering about 30 km^2, running NW-SE, west of Kiev, in Volynia
Finds: First reported emerald finds in 1968; exact locality unknown; no confirming specimens
Beryl: Grass-green, yellow-green to olive-green crystals, often of irregular habit due to solution processes; colored by 0.04% chromium oxide
Geo: Very localized emerald mineralization at reaction contact between pegmatites and ultrabasics
Mat: Quartz-feldspar rocks and phlogopite schists
Incl: Phlogopite, tourmaline, garnet, quartz, K-feldspar, white mica, etc.
Ref: Lavrinenko et al. (1971)

North America

NORTH CAROLINA • Hiddenite

Rist and Ellis Property NE of the community of Hiddenite, Alexander Co., North Carolina
Finds: First finds in 1875 by the collector J.A. Stephenson; the light green variety of spodumene hiddenite was discovered in 1880 by W.E. Hidden in a vug near emerald crystals; emeralds up to 11 cm long and 1,686 ct
Beryl: Colored pale green, blue-green, emerald green by chromium
Geo: Precambrian quartz-mica schist and gneiss cut by quartz-mica veins of pegmatitic origin; emeralds and other minerals in vugs and druses in the veins; the whole series is deeply weathered to a red clay
Mat: Quartz-mica veins in weathered mica schists
Sim: Gemstone Haven south of Spruce Pine; Turner Mine near Shelby in Cleveland Co.; Crabtree Emerald Mine, Big Crabtree Mountain in Mitchell Co.
Incl: Rutile, tourmaline, monazite, quartz, muscovite, pyrite, albite; innumerable macroscopically visible hollow channels
Ref: Brown & Wilson (2001); Sinkankas (1982)

CANADA • Finlayson Lake

Regal Ridge: Goal Net Property in the Finlayson Lake District, southeastern Yukon
Finds: Deposit, first called "Crown Showing," discovered in Sept. 1998 by William Wengzynowski, crystals to 4 cm; good gemmy material available
Beryl: colored green by chromium (to 0.8%) and vanadium (max. 0.03%); gemmy crystals
Geo: Hydrothermal alteration of a volcano-sedimentary series in the Yukon-Tanana terrain; emeralds are limited to scheelite-bearing tourmaline zones in quartz veins cutting across the mica-rich portions of chlorite-mica schists; assumed to be related to a nearby two-mica granite pluton (U-Pb age 112 million years)
Mat: Jarosite-tourmaline zones and quartz veins
Incl: Calcite, quartz, tourmaline (dravite-uvite-dominant), chalcopyrite, pyrite, molybdenite, scheelite, zircon, chromite, ferberite and hematite
Ref: Groat et al (2001)

South America

COLOMBIA - Western Zone in the Eastern Cordillera

Vasquez-Yacopí mining district with Coscuez, Yacopí, Muzo (with Tequendama, Palo Blanco and Puerto Arturo), Peñas Blancas and Maripi
Finds: See pages 36 to 45; crystal size to 6 x 10 cm, or 4,000 ct; largest emerald, the *Muzo*, weighs 16,020 ct
Beryl: Wide color spectrum and range of transparencies; trapiche emeralds from Muzo and Coscuez; very rarely also cats eyes; colored by vanadium, chromium and iron

NORTH CAROLINA: Emeralds from the Rist Mine; the large crystal measures 10.5 cm. Harold & Erica van Pelt photo.

Geo: Emeralds occur within a thick sequence of Cretaceous black shales and limestones. Mineralizing solutions were sulfate-bearing, evaporate-derived brines. Upon encountering organic matter in the shales, the sulfate was thermochemically reduced to produce hydrogen sulfide; organic matter was consumed in the process releasing beryllium, chromium and vanadium into solution. The pressurized solutions brecciated sur-

rounding host rock before depositing emeralds. Muzo and Coscuez emerald deposits formed respectively 32 and 35-38 million years ago.
Mat: Emeralds occur within a stockwork of albite, pyrite and calcite bearing veins. Accessory minerals, fluorite and parisite are used by miners as indicators of emerald mineralization. Apatite, tourmaline and barite have been reported
Sim: Minabuco, Repolal, Pava, Cincho, Los Cristales, Quaquimay; the mines from the Maripi district are La Pita, Polveros, Casa de Lata, Las Cunas, Chizo between Muzo and Coscuez along the Rio Minero River
Incl: Carbonates, quartz, albite, bitumen, parisite, pyrite & green muscovite
Ref: Cheilletz et at (1994); Ottaway et al (1994); Giuliani et al (2000)

COLOMBIA • Eastern Zone in the Eastern Cordillera

Guavió-Guatéque mining district with Chivor, Gachalá (Vega San Juan, Las Cruces, El Diamante, El Toro, Mantecanã) and Macanal
Finds: As in the western zone, Chivor mining district was the classic occurrence in the eastern district, but its current share of total production is only 5 percent
Beryl: As in the western zone but without trapiche emeralds
Geo: As in western zone, but the Chivor emeralds are older than those of Muzo and Coscuez. They formed 65 million years ago.
Mat: Veins, fissure and cleft fillings in black shale breccias with albite, pyrite, quartz, dolomite, calcite, and muscovite; alteration products: goethite, kaolinite, sericite, halloysite, allophane and hyalite
Sim: Buenavista, La Guala, El Pulpito, Klein, Oriente, Palo Aranado, Guali and Quebrada Negra
Incl: Bitumen, graphite, dolomite, albite, calcite, pyrite, green muscovite and quartz
Ref: Schwarz (1992); Cheilletz & Giuliani (1996); Branquet et al (1999)

BRAZIL • Bahia, Salininha

Pilao Arcado district: occurrences on the Fazenda Sao Thiago on the Western bank of the São Francisco River half way between Xique-Xique and Remanso
Finds: First finds reported around 1962; no commercial significance
Beryl: Vanadium beryls: pale to medium-green by vanadium (0.0 to 0.48%), iron (0.4 to 0.8%) and little chromium (up to 0.03%); crystals generally turbid and small
Geo: A series of migmatic gneiss, amphibolites, quartzites, itabirites and mica schists with ultrabasic bodies; emeralds in contact zones between kaolinized pegmatites and carbonate-chlorite-talc schists
Mat: Feldspar pockets (kaolinized), quartz lenses, phlogopite schists, and chlorite-carbonate-talc schists
Incl: Quartz, carbonates and biotite
Ref: For all Brazilian deposits: Schwarz (1990); Giuliani et al (1997); Roditi & Cassedanne (1998)

BRAZIL • Bahia, Carnaíba

8 km SW of Campo Formoso on the western flanks of the Serra de Jacobina. Carnaíba de Baixo district: Bode, Lagarta, Gavião, Formiga, Laranjeiras, Arrozal, Braulia and Marota prospecting pits; Carnaíba de Cima district: Trecho Velho, Trecho Novo, Bica, Cabra prospecting pits
Finds: Discovered in 1963; variable chromium content (0.1 to 0.8%), iron (0.17 to 1.07%), vanadium (0.01 to 0.08%); often distinctly color zoned
Geo: Deposits in the metasedimentary series of the Serra de Jacobina, composed of schists, quartzites and serpentinites; emerald contained in phlogopite schists at the contact between Be-bearing pegmatites and serpentinites; emerald 1.99 billion years old
Mat: Phlogopite schist and desilicated pegmatites (albitites)
Incl: Phlogopite, tremolite-actinolite, tourmaline, plagioclase, K-feldspar, muscovite, margarite, calcite, dolomite, quartz, apatite, rutile, chlorite, talc, allanite, fluorite, scheelite, rhodonite, molybdenite, chromite, chalcopyrite, phenakite, goethite and lepidocrocite
Ref: Couto & Almeida (1982); Giuliani et al (1997)

BRAZIL • Bahia, Socotó

20 km NE of Campo Formoso; Trecho Novo, Munde
Finds: First finds in 1983; crystals to 8 cm; few of gem quality
Beryl: Crystals often with distinct color zoning, core colorless, green rim, colored by chromium (0.05 - 1%), iron (0.2 to 1.1%) & vanadium (to 0.04%)
Geo: Intrusion of pegmatites of the Campo Formoso granite into serpentinites from the volcano-sedimentary series of the Serra de Jacobina; classic genesis type, emeralds formed 1.98 billion years ago in phlogopite schists at the contact between pegmatite and serpentinite.
Mat: Phlogopite and actinolite-tremolite schists and feldspar albitites
Incl: Biotite, actinolite, quartz and plagioclase (albite-oligoclase)
Ref: Giuliani et al (1997)

BRAZIL • Bahia, Brumado

Earlier, Bom Jesus das Meiras, large open pit near the town of Vitoria da Conquista
Finds: Discovered in 1912/1913; glory days of emerald production early 1920's; later only sporadic activity; at present buried
Beryl: Pale green crystals, chromium (to 0.06%), iron (to 0.52%) and vanadium (to 0.03%)
Geo: Precambrian dolomitic marbles cut by talc lenses, amphibolite dikes and granites; Fazenda Pombos deposits formed 502 million years ago, deposits Juca 490 million years ago
Mat: Emerald crystals in druses or geode-like vugs, associated with quartz, magnesite, dolomite, tourmaline, topaz, hematite and kyanite
Sim: Anagé district with mines of Açude do Sossego, Fazenda Pombos, Piabanha, Fazenda Lagoinha, Fazenda Açude, Juca and Lagoa Funda in phlogopite schists
Incl: Quartz, carbonates, tourmaline and talc
Ref: Just (1926); Giuliani et al (1997)

BRAZIL • Ceará, Tauá

Occurrences on the Fazenda Boa Esperanza near Tauá
Finds: Commercially insignificant; gem quality rare

Beryl: Colored pale to medium-green by chromium (0.13 to 0.90%), iron (0.2 to 1.17%) and vanadium (to 0.06%)
Geo: Precambrian series with amphibolites, augengneiss in amphibolite facies, enclosing pegmatite dikes and lenses with columbite-tantalite, native bismuth, beryl and cassiterite; age of the emerald formation is 764 million years old
Mat: Phlogopite schist, actinolite schist and chlorite schist
Sim: Coqui formed 516 million years ago
Incl: Actinolite-tremolite, phlogopite, quartz, plagioclase, apatite and molybdenite
Ref: Branco et al (1984, 1988)

BRAZIL • Minas Gerais, Belmont

The Belmont Mine in Minas Gerais, 13 km NE of the town of Itabira, 120 km SE of Belo Horizonte
Finds: Belmont Mine founded in 1977; 1988, new finds near Nova Era; since 1990 the richest district in Brazil, locally outstanding gem quality
Beryl: Colored pale green to saturated green by chromium (0.06 to 1.42%) and iron (0.2 to 1.3%); well-developed prismatic crystals to over 10 cm
Geo: Precambrian series of strongly folded schist and light gneiss cut by small pegmatite bodies; emeralds formed during regional metamorphism in the greenschist to amphibolite facies conditions
Mat: Phlogopite schist, chlorite schist and quartz lenses
Sim: Nova Era (Capoeirana) 10 km SE of the Belmont Mine forming 508 million years ago; Santana dos Ferros (Oliveira Castro mine) near the community of Esmeraldas; newest occurrence discovered in 1998: Piteiras
Incl: Chrysoberyl, phlogopite, chlorite, quartz, molybdenite, talc, carbonates, apatite, actinolite-tremolite, plagioclase, chromite and pyrite
Ref: Souza et al (1992)

BRAZIL • Santa Terezinha

In the center of Goiás, near the mining community of Campos Verdes
Finds: Discovered accidentally in April 1981; production of emerald rough rose from 35 kg in 1981 to 52 tons in 1988; present production is insignificant
Beryl: Colored green by chromium (0.053 to 1.54%), iron (0.48 to 1.82%) and vanadium (0.06 to 0.08%); highest chromium and iron contents of any Brazilian emerald; often sharply zoned with colorless core and green outer zone; rarities are cat's eye stones up to 6 carat
Geo: Stratabound mineralization in fold structures along the plane of along the plane of foliation in talc schists of the Precambrian volcano-sedimentary series of the Santa Terezinha within greenschist facies metamorphic overprint; the Santa Terezinha emerald deposit is 522 million years old
Mat: Talc schist, phlogopite schist, tremolite-phlogopite-talc-chlorite-carbonate schist and quartz-carbonate lenses, quartzite
Sim: Porangatu, Fazenda das Lajes (Itaberaí) and Pela Ema-Minaçu
Incl: Carbonates, sulphides, talc, phlogopite, quartz, feldspars, amphiboles, epidote, garnet, rutile, spinels, hematite and ilmenite
Ref: Biondi (1990); Giuliani et al (1990, 1997)

BRAZIL • Goiás, Pirenopólis

120 km W of the capital city of Brasília, 18 km NW of Pirenopólis
Finds: Discovered by Brazilian geologists in 1977; crystals up to 0.5 x 1.5 cm were found
Beryl: Colored green by chromium (to 0.41%); good quality only in phlogopite schists, otherwise only faintly green to colorless
Geo: Cassiterite and fluorite-bearing pegmatites and greisen at the contact between a granite and garnet-muscovite schists and serpentinites; intense alteration to albite, tourmaline, zinnwaldite and phlogopite; emerald formed 650 million years ago
Mat: Phlogopite schist, actinolite schist, albitite and serpentinite
Incl: Phlogopite, actinolite-tremolite, apatite, zircon, quartz, albite, tourmaline, cassiterite and talc
Ref: Araujo & Leonardos (1986); Giuliani et al (1997)

BRAZIL • Tocantins

Monte Santo Tocantins occurrence, 30 km NW of Paraiso de Tocantins, 100 km W of the capital city Palmas, Federal state of Tocantins
Finds: Most recent emerald fever in Brazil; since 1998 in several areas around Monte Santo
Beryl: Pale green to dark green emerald colored by chromium and iron; crystal sizes about 0.5 to 2 cm
Geo: Emerald mineralization in phlogopite schists formed during metasomatism between Be-rich quartz-feldspar-mica rocks and talc schists
Mat: Tremolite-actinolite, chlorite, talc and phlogopite schists

SOCOTO: 3 cm long emerald with molybdenite. Wolfram Schäfer collection; Maximilian Glas photo

Incl: Actinolite, tremolite, chlorite, talc, phlogopite, apatite and quartz
As we go to press, this is the world of emeralds. The following pages take a closer look at today's producing districts, as well as one old deposit with new potential. The most significant productive deposits today lie in South America, Africa and Asia.

Grundmann G., Giuliani Gaston.

Emeralds of the world : notes on known emerald occurrences.

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