

Science Camp #170802.8

02-04 August 2016 @ the Condo, the Nelson Cabin, and surrounding area



Advisors

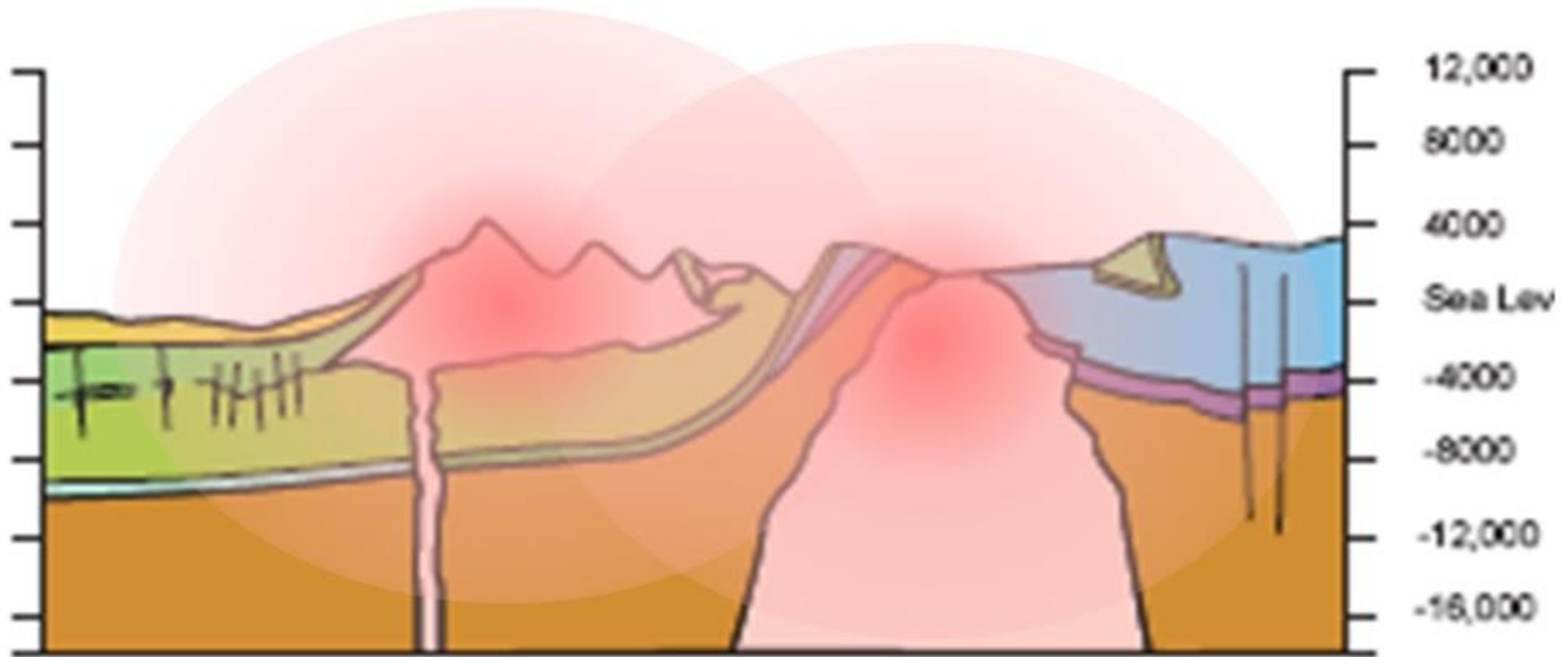
H. Roice Nelson, Jr., Andrea S. Nelson,
Paul F. Nelson, Benjamin B. Nelson



Attendees

Ethan E. Nelson, Grant M. Nelson, Colby C. Wright,
Taylor R. Wright, Ella D. Nelson, Halle N. Wright,
Bobbie Sophia Waldron, Dallin Spencer Nelson,
Avalyn Joyce Wright, Rachel Lee, & Ian Lee

Temperature Cooks Off Hydrocarbons and Creates Mineralization

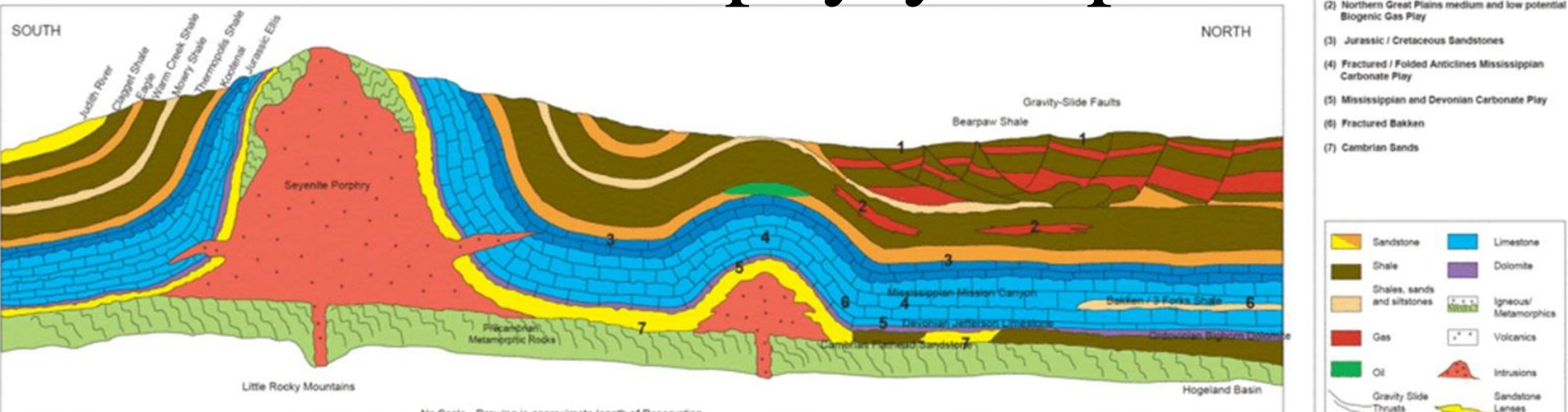


Temperature Anomalies from Intrusive Rocks



Mineralization Occurs in Heated Fluids in Faults

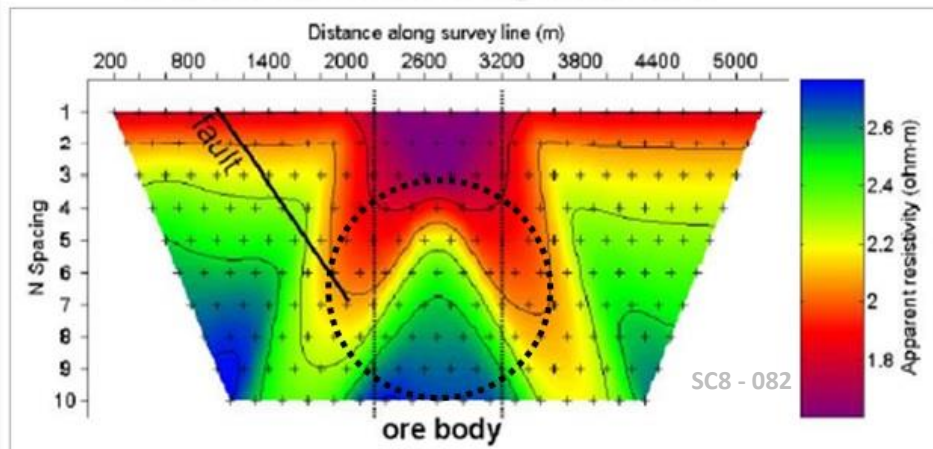
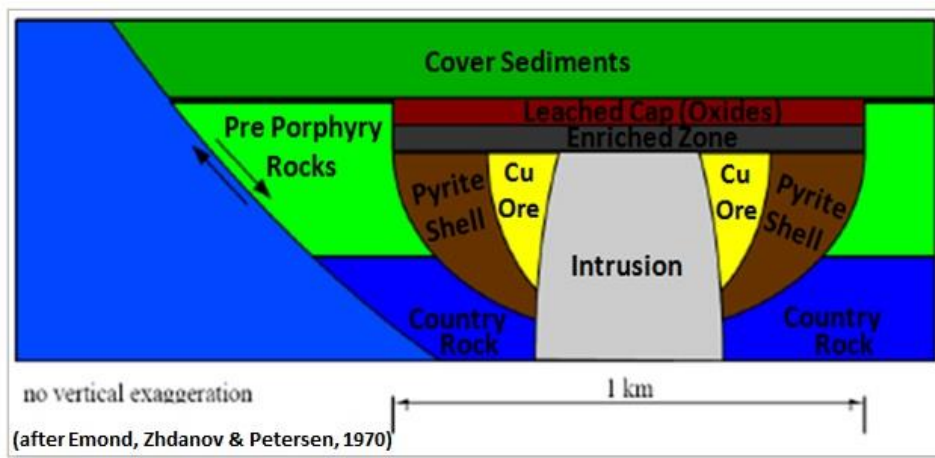
Intrusions and Porphyry Deposits



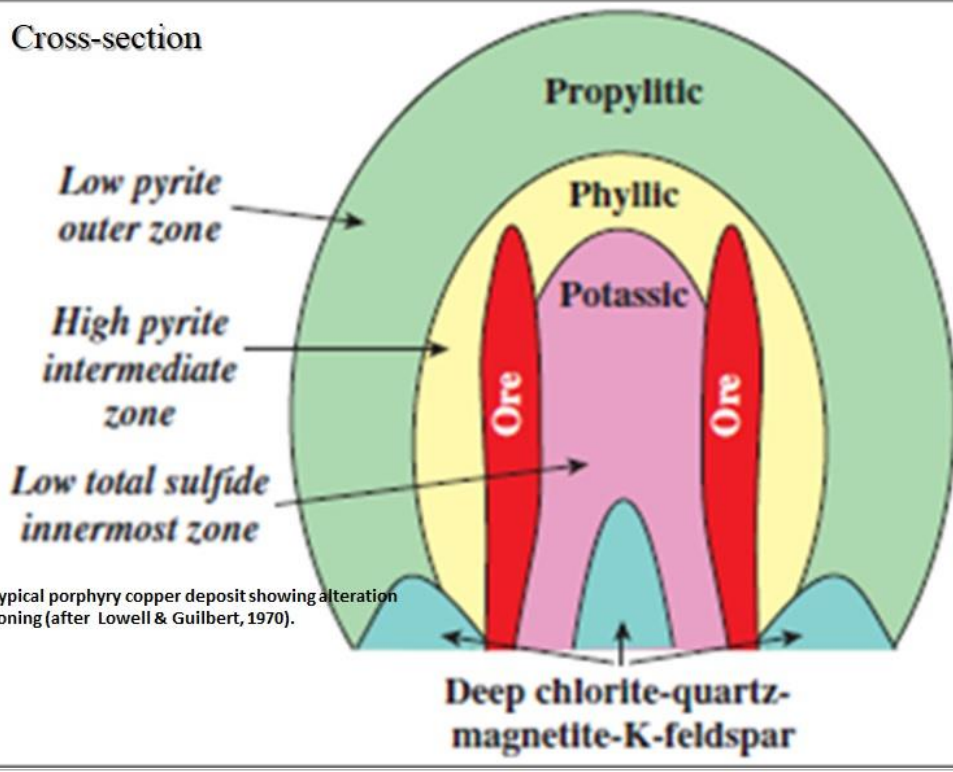
Simplified Porphyry Copper Deposit Model

Typical Mineral Zones of a Porphyry Deposit

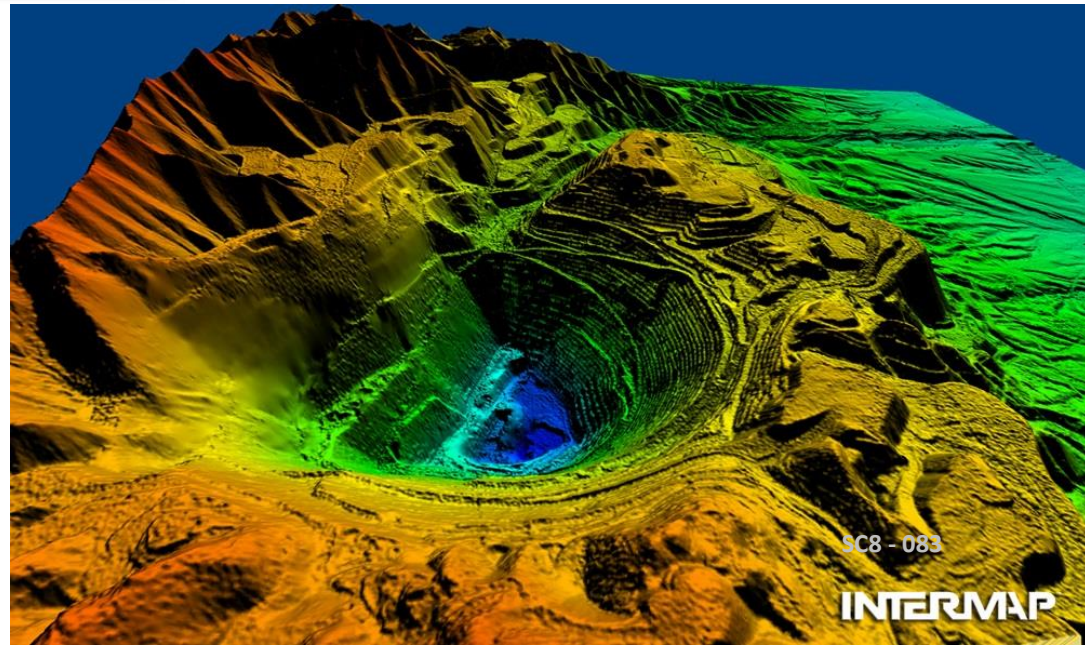
Conductivity anomaly surrounds more resistive ore body in center.



Cross-section



Kennecott Copper Mine is an Example of a Copper Porphyry Deposit



Sedimentary Rocks





Chalcedony, Glitter Rocks, & Obsidian



Red Rocks & Wonder Stone



Temple Agates



Blue & Pigeon Blood Agates

SC8-085



Azurite & Malachite

Volcanic Rock & Gold Matrix



Pyrite

Moapa Volcanic Glass

SCB-086

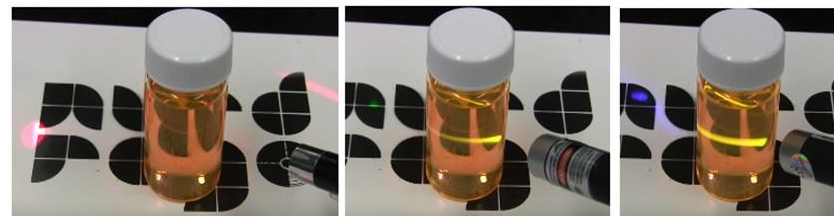
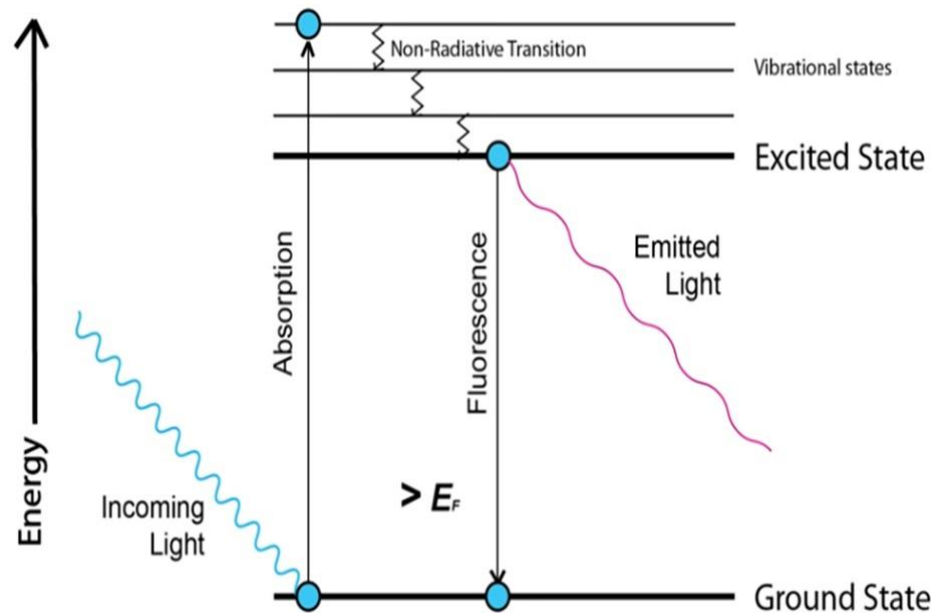


Moqui Stones



Holt Canyon Jasper & Dugway Geodes

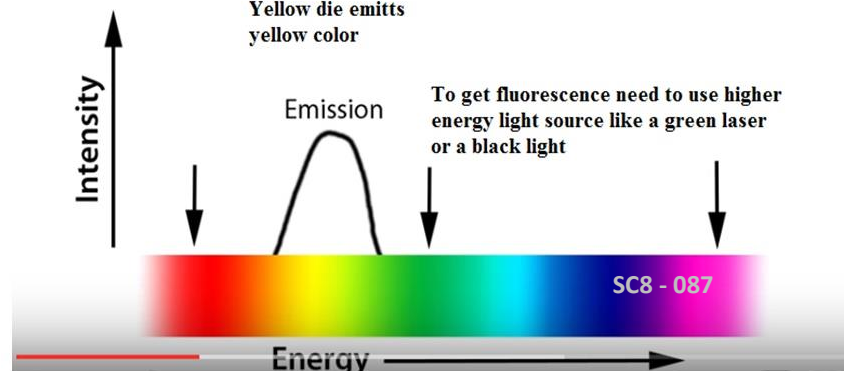
Fluorescent Rocks



Red laser
no fluorescence

Yellow die emits
yellow color

To get fluorescence need to use higher energy light source like a green laser or a black light





Is it an accident these rocks are here?

SC8 - 088

Sunstones and Topaz deposits are associated with lightning mappable underground geologic processes



Sunstones collected at Sunstone Knoll, Millard County.



Topaz crystals.



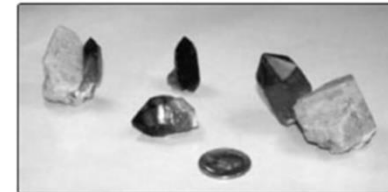
One of the numerous pits that collectors excavated in their search for topaz and other minerals.

Other Rocks In the Area

Smoky Quartz vugs tie hydrothermal alteration

Geologic information:

The Mineral Mountains, located in Beaver County, make up the largest exposed plutonic body in Utah. Rock compositions range from quartz monzonite in the northern half of the pluton to granite around Rock Corral Canyon in the south. Excellent crystals of smoky quartz and feldspar are found in vugs or cavities in the granite. They formed when cooling fractures in the granite were filled by late-stage pegmatites consisting of quartz, microcline, and plagioclase. Quartz occurs as clear to smoky, euhedral crystals up to three inches long while microcline is commonly found as euhedral, equidimensional crystals averaging approximately 0.75 inches in width. Occasionally, large pseudomorphs of limonite after pyrite can be found in these areas as well.



Trilobites



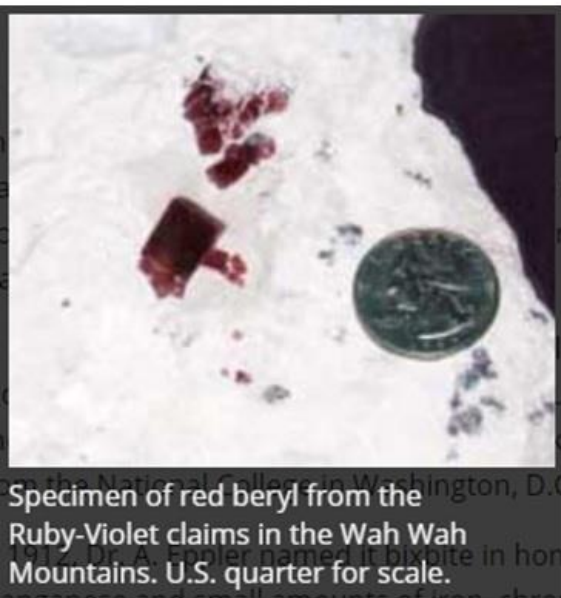
Abundant trilobite fossils, including *Elrathia kingi* shown here, can be found within the Wheeler Shale east of Notch Peak in the House Range. Many of the dry desert peaks of western Utah tell a story of shallow tropical seas. As much as 500 million years of deep burial, uplift, and erosion have changed layers of organic mud to cliffs and ledges of layered limestone. Closer inspection reveals abundant fossils, evidence of ancient sea life. Notch Peak, House Range, Millard County, Utah Photographer: Michael Vanden Berg



Cambrian-age shales from western Utah's House Range contain millions of fossilized trilobites, such as this specimen of *Elrathia kingi*. Trilobite, House Range, Millard County, Utah Photographer: Michael Vanden Berg

Very Rare Gems

Red & Green Beryl are a direct result of hydrothermal alteration



Specimen of red beryl from the Ruby-Violet claims in the Wah Wah Mountains. U.S. quarter for scale.

THE GEOLOGY OF... Emeralds

Green Gold Oh, what a little hot water can do to boring old shale

BY ROBERT KUNZIG

Before the Spanish conquest of what is now Colombia, people in the mountains north of Bogotá are said to have thrown emeralds into Lake Guatavita. Once a year the Indian ruler would cover himself with honey and gold dust and at daybreak have his men row him out into the lake. As he plunged into the water, offering the gold to his god, the crowd on shore would throw in their own offerings. The rich ones chucked in emeralds.

When the Spaniards finally found the Indian emerald mines after decades of bloody searching, the Old World went crazy for the New World's gems. Although the Egyptians had begun mining emeralds near the Red Sea as early as 1650 B.C.—and emeralds had long been symbols of immortality, cures for dysentery, and preservers of chastity—the new Colombian gems were the clearest, biggest, and greenest anyone in Europe had ever seen. They still are: the same mines remain in operation, accounting for 60 percent of the world's production.

Emeralds are valuable because they are rare, rarer than diamonds. They are rare, says geologist Alain Chaillet, of the Center for Petrographic and Geochemical Research in Nancy, France, because they are a mixture of elements that

because a few of the aluminum atoms in their crystal structure have been replaced by atoms of chromium or vanadium. Neither of those elements has any reason to meet up with beryllium; they and it belong to two different chemical families that drifted apart billions of years ago.

Soon after Earth was born, when it was young and mostly molten, a lot of silicon and aluminum rose to the surface, like a kind of scum, then cooled, forming the first continents. Most of the iron stayed behind in the mantle or sank into the planet's core. Other elements, those one of those two fates, too, based on their weight and size.

Because of this parting of the elements, Earth's surface rocks are segregated into two realms, like yang and yin: light and dark, crust and mantle, continent and ocean bottom. Geologists call the light minerals felsic and the dark ones mafic. The pantheon of the emeralds, as Chaillet calls it, is that beryllium belongs to the light, felsic, continental side, whereas chromium and vanadium are from the dark, mafic, oceanic side. Emeralds, in other words, are yin and yang in a single crystal.

"The whole problem in our research," says Chaillet, "was to figure out the geologic conditions that could permit these two elements to meet at the same time and place."

The answer, they discovered, has to do with plate tectonics, the ceaseless shifting of Earth's crust that smashes continents together to build mountains. Every now and then, when an ocean disappears between two colliding continents, a chain of volcanic islands or a slab of seafloor gets beached on land. As a result, the continental crust has over the eons lost its original purity; it has become a patchwork



A sparkling Colombian emerald born of the drabdest black shale.

For centuries emeralds were thought to cure dysentery and even preserve chastity

don't ordinarily get a chance to mix: "They are a mineral that shouldn't exist at all."

An emerald is a type of beryl, a mineral made of beryllium, aluminum, silicon, and oxygen. All those elements are common in the continental crust, so beryls are not rare. But whereas ordinary beryls are colorless, emeralds are green

that includes oceanic rocks, and thus traces of chromium and vanadium, along with the continental rocks that are laced with beryllium.

To make an emerald, though, those elements have to come together in a single hot liquid. The most common place for it to happen is underneath a young mountain

THE GEOLOGY OF... Emeralds

range. Where the edges of two colliding plates stack up, continental rocks can get dunked so deep into Earth that they melt again, liberating a great balloon of magma that rises back through the crust. At a depth of around six miles, the magma reaches its level of neutral buoyancy, stops, and begins to cool and solidify as granite. From the top of this cooling mass, streams of superhot, mineral-laden water—granite juice—migrate upward into fissures in the surrounding rock and begin to leach out elements.

Ninety-five times out of a hundred that surrounding rock is some ordinary bit of continent, and nothing terribly novel happens. "But if by chance the granite happens to hit a zone of mafic rock incorporated in the continental crust, then the chemistry will be completely different," says Chaillet. "It will include iron, magnesium, and calcium—and traces of chromium and vanadium." When the felsic-mafic mixture finally freezes, the fissure will be filled with biotite, a kind of mica—black, flaky, and useless. But scattered through the mica, like green snowflakes, may be emeralds.

Most of the world's known emerald deposits, from the 3-billion-year-old ones in South Africa to the 9-million-year-old ones in Pakistan, were formed by granite intru-

According to Giuliani and Chaillet, those ingredients came together on two distinct occasions, 65 million and 38 million years ago. Surges in plate motions—the Atlantic Ocean was getting wider, pushing South America against the Pacific and raising the Andes—caused the thick stack of sediments under the shallow sea to buckle. Large sloping faults formed several miles down in the sediments, and hot water was squeezed out of them, escaping upward along the faults. Rising through layers of salt, the 570-degree water became extremely corrosive. Continuing through layers of shale, it dissolved out the emerald ingredients. Finally it pooled under a layer of especially impermeable shale until the pressure became great enough to shatter that layer explosively.

Then the hot solution shot up through empty cracks in the rock. As its temperature and pressure plummeted, emerald crystals snowed out of it immediately. It all happened so fast, says Giuliani, that the emeralds had no time to grow around grains in the surrounding shale. They grew unconstrained and pure, without the minerals that often cloud emeralds found in other parts of the world. That is why Europeans were so enraptured with the Colombian stones when they first laid eyes on them in the sixteenth century.

Like other emeralds, those from Colombia contain tiny pockets of fluid, typically no more than a hundredth of an inch across—gardens, as they're called in the gem trade. If you look at one of the Colombian gardens under a microscope, says Giuliani, you will see that it contains a crystal of salt, ordinary sodium chloride. The crystal is a trapped fossil of the brine from which the emerald itself crystallized, tens of millions of years ago.

Inside each emerald is a small pocket of fluid, called a garden. In the fluid is a crystal of salt. Often that microscopic evidence is the only way to tell a fake

sions. In the 1980s, Chaillet and his colleague Gaston Giuliani studied deposits like that in Brazil. Then they went on to Colombia to have a look at the most renowned emerald mines—and soon saw that they didn't fit the standard picture. "In Colombia, geologists had been looking for granites but not finding them," Giuliani says. "When I arrived, I saw right away that the rocks were not the same."

Instead of granites intruding from below, in Colombia there are black shales laid down from above—sedimentary rocks deposited on the floor of a shallow inland sea during the Cretaceous Period, 100 million years ago. The sea must have been shallow, because the shales are sandwiched among layers of salt, which precipitated out of the water at times when it had all but evaporated. Black shales, besides being progenitors of oil fields (of which Colombia has a few), also made up everything that washed off the various rocks that made up the neighboring land. The Colombian shales contain, in dispersed form, all the ingredients of emeralds.

Except for those inclusions, emerald manufacturers today are able to mimic natural processes so well that it can be difficult for a layman to tell synthetics from the real thing. Perhaps that's one reason emeralds don't pack the same emotive resonance for us that they did for bygone Indians and kings. We no longer see links to divinity or immortality in an emerald's limpid green depths. What we might imagine is the stone's history: the entire history of the planet distilled into a single miraculous (scientifically speaking) crystal. That's resonance enough for a rock. ■



Notes

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2017 Science Camp

- What was best about 2017 Science Camp?

- _____
- _____
- _____

- What would be your ideal 2018 Science Camp Theme?

- _____
- _____
- _____