Features

A cold geyser appears to be a contradiction in terms. But a combination of carbon dioxide, effervescing groundwater and a fortuitous oil exploration well can create a very spectacular water fountain.

Crystal Geyser – Utah's cold one

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Nearly 600 km south of Yellowstone, Utah has its own erupting geysers. Crystal Geyser is the biggest and best – and it's cold. There's no geothermal heat and no steam flashing. Instead, it is driven by carbon dioxide, and there are many similarities with the hot geysers in the cyclic production of gas to power the water fountains. Cold geysers are not entirely natural, as they rely on man-made bored wells to provide their conduits to the surface. But once the well is in place, the periodic eruptions are all natural.

Crystal Geyser lies in the semi-desert of northern Utah, out in the wilderness on the bank of the Green River, 6 km south of the town of Green River (Fig. 1). Country rock at the geyser is the almost flat-lying buff Entrada Sandstone (well known at Arches National Park, not far to the south) surrounded by other sandstones and shales of the Jurassic–Cretaceous sequence; away to the north, the Book Cliffs rise to their Tertiary caps. The Little Grand Wash Fault is hardly a major feature, but it constitutes a groundwater conduit from deep artesian aquifers. Its outcrop is marked by patches of calcite travertine, both old and active, and also by seeps of oil and gas.

Any sign of oil attracts the drillers, and the Glen Ruby No.1-X exploration well was drilled in 1936. It was sited right in the middle of a big bank of travertine on top of the Little Grand Wash Fault, where it crosses under the east bank of the Green River. The well's targets were potential fault traps and structural traps in a gentle anticline immediately north of the fault. It was drilled to a depth of 800 m, found nothing of value, and was abandoned. The top of the steel well casing, 250 mm in diameter, still protrudes a metre or so from the ground (Fig. 2). Most of the time, groundwater stands many metres down, probably at close to the level of the adjacent river. But every 12 hours or so, it erupts into a splendid geyser.

Eruptions

The eruption cycle is classic. The first sign of a rising water level is the filling of the pool around the casing. Water leaks into the pool just below the surface, and it starts to bubble and gently foam. It stays cold; most of the gas is carbon dioxide, but the smell indicates a touch of sulphurous gases. This lasts for 5 minutes,

Fig. 1. The Crystal Geyser site, beside the Green River. Travertine covers most of the foreground. The well casing is visible within the dark area of the water that has just emerged during an eruption. The white areas are gypsum crusts. Dark patches on the river are floating ice, as the picture was taken in January.

Fig. 2. The protruding well casing just after an eruption when the surrounding travertine is wet, but water level has fallen in the pool around the well.

Fig. 3. An eruption starts as the effervescing water rises higher and faster within the well.

before it goes quiet again for about 10 minutes. Then the frothing starts again, and the groundwater column rises inside the casing – indicated by the miniature spouts out through some bullet holes (this is the American West!). The frothing and spouting become more and more vigorous for about 5 minutes, until the effervescent water foams and squirts out of the top as the proper eruption starts (Fig. 3). In a series of pulses, this builds up into a magnificent geyser with bursts to over 20 m high (Fig. 4). With no steam to hide behind, it is every bit as spectacular as its Yellowstone cousins.

Within 5 more minutes the eruption is over; some water drains back into the well, and all is quiet again. Two muddy pools close to the geyser are fed by groundwater that is clearly linked to the well supply. Their levels fluctuate and they have periods of effervescence during the eruption cycle.

Fig. 4. Crystal Geyser in full eruption.

Source of the carbon dioxide

The immediate source of both the water and the carbon dioxide in Crystal Geyser is almost certainly the Navajo Sandstone, reached at a depth of about 215 m in the well. Along with the Wingate Sandstone, and with impermeable shales both above and below, this constitutes a major aquifer fed from outcrops on the San Rafael Swell 25 km to the west. The fountaining water contains over 12 000 ppm of dissolved salts, largely derived from the Navajo Sandstone, but possibly also by saturated seepage from evaporites deeper down in the Carboniferous sequence. The main source of the carbon dioxide is thought to be a reaction between acidic groundwater and the carbonate fractions within the Navajo sandstone. The contribution of meteoric and soil gas is likely to be small in the desert climate, and there is debate over the role of deeper warm waters in the carbonate breakdown.

Whatever its source, the carbon dioxide content of the groundwater is high under the hydrostatic pressure induced by depth. As more is generated, the water becomes saturated with the gas, which therefore starts to exsolve. The column of water in the well conduit therefore starts to effervesce, and pushes water out of the top of the well. Less water in the well conduit causes a reduction of hydrostatic pressure in the aquifer, and in turn causes more carbon dioxide to be exsolved. This is a chain reaction, very similar to the flashing of steam due to reduced pressure in a conventional hot geyser. But in the case of Crystal Geyser, the process is more akin to an effervescing bottle of champagne. The rapidly generated gas drives the eruption, until gas and water achieve a new equilibrium under lower pressure. Then all is quiet, while dissolved gas accumulates until the cycle can repeat.

Travertine

The water that erupts from Crystal Geyser is rich in dissolved minerals. Most noticeable are the carbonates that are deposited as great banks of travertine. The original well was drilled in the middle of a travertine bank, and only passed into country rock at a depth of 20 m. New travertine deposited by the geyser water now spreads over this, covering an area 40 m across (Fig. 1). It forms miniature terraces each about 5 mm high (Fig. 5). Between eruptions, these dry out to expose floors of crumbly crystals behind the tiny gour pool rims, all stained yellow by iron oxides, but most are recharged with mineralized water from each eruption. In addition, the salt content of around 8000 ppm contributes to the salinity of the Green River. Though this is undesirable, with respect to abstraction downstream, the geyser's well has merely localized the flow of the many small springs that used to feed saline water up the Little Grand Wash Fault and then into the river; these sites remain marked by banks of inactive travertine.

Historical changes

In 1973, Crystal Geyser erupted every 4 h 15 min. In 1990, eruptions were every 12–18 h, and are about every 12 h today. Back in 1973, the discharge from a single eruption was measured at 120 m^3. This is a huge volume of water, and the current discharge is estimated at no more than 25 m^3. Some local people ascribe the decline in activity to the dynamiting of the well by the disgruntled landowner midway through an access dispute with state authorities; this is very plausible, but the story could be difficult to verify.

Crystal Geyser is not the only erupting oil well in Utah. Tenmile Geyser is on another fault system parallel to Little Grand Wash about 6 km to the south, but its rather rare eruptions rise no more than one or two metres. Between Green River town and the Book Cliffs, Woodside Geyser erupts briefly to about 10 m but currently less than once a day.

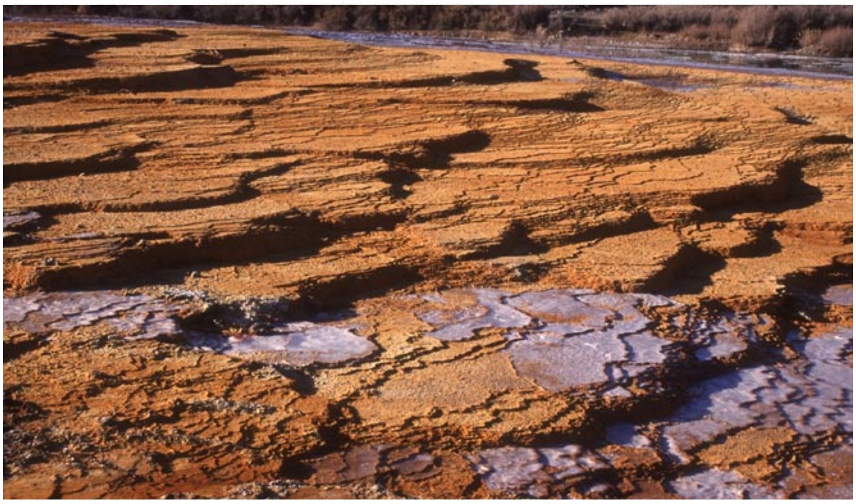

Fig. 5. Miniature terraces of travertine that extend away from Crystal Geyser, dry before an eruption.

A visit to Crystal Geyser can be worthwhile. From Green River town, head east to the freeway junction, and continue east on the southern frontage road. About 4.5 km along this, turn south (by a small signpost) onto a good dirt road. After about 6.5 km, latterly along the Little Grand Wash Fault valley, keep right at a signposted fork, and the track ends at the geyser. The chances of seeing an eruption on a short visit are statistically low, but the travertine is spectacular – and it's a lovely isolated spot for a picnic.

Suggestion for further reading

Baer, J.L. & Rigby, J.K. 1978. Geology of the Crystal Geyser and environmental implications of its effluent, Grand County, Utah, *Utah Geology*, v.5, pp.125–130.