Geyser watching

TONY WALTHAM

Yellowstone is justifiably famed for its geysers, but Iceland, New Zealand and Kamchatka all have their own special geothermal features.

Everyone likes to see geology in action, but geological time scales rather limit the opportunities. Volcanic eruptions can provide the ultimate in natural spectacle, but timing is of the essence, and Britain is not well located for an eruption-spotter. Geysers are the next best available, and some are reliable enough to become major tourist destinations.

Geysers are the highlights of any geothermal area that may also contain hot springs, boiling pools, mud volcanoes, sinter terraces, fumaroles and solfataras. All these features are the consequence of underground heat flows that are high enough to drive rain-fed groundwater back to the surface, largely by its lower density at high temperature. Steam generation at the lower pressures in shallow ground then drives the more explosive features. The ultimate source of the heat is always magma, at depths generally of two or three kilometres. Geothermal phenomena are short-lived in geological terms; they are commonly the end stages of volcanic activity that has produced eruptions in the recent past, or will do so in the near future.

Fig. 1. Strokkur, Iceland's still active geyser in full eruption. (Photos: Tony Waltham.)

Vents that produce steam alone are fumaroles, or solfataras if laden with sulphur; impressive, but rarely exciting, they are more common on drier volcanoes than in hydrothermal basins. Vents that produce an almost continuous fountain of water are known in Russia as spouters; they're a bit better, but are unusual because they require such a delicate equilibrium between heat and water flows. Much more exciting are true geysers, with their intermittent eruptions of high water jets (Fig. 1). They are all named after the number one geyser in Iceland. Geyser is simply the Icelandic word for a waterspout. They spell it *geysir* and pronounce it *gay-zear*; elsewhere the spoken word has changed to *guy-zer* or *gee-zer* (but don't use the latter in America, where it refers to an old guy with a bottle of firewater).

The mechanics of a geyser eruption have been long debated, but it is now recognized that the key lies in the flash production of steam. Groundwater within a deep network of fissures is warmed by geothermal heat. Eventually, steam bubbles are produced as the water boils at well above 100 °C at the high pressure created by the head of water above it. The expansion into steam forces some water up and out of the geyser vent, where an increasing flow is generally a sign of an impending eruption. Less water in the column means less pressure, and therefore a lower boiling point. So more superheated water turns to steam, and a chain reaction has started. The effect of the pressure drop is that a lot of water flashes into steam very quickly and drives the eruption. It all finishes when too much heat is lost and cooler water flows into the system. The period of recycling is a complex function of the geyser's thermal dynamics and its fissure system geometry, neither of which is predictable except by interpretation after long observation of the eruptions. Because heat flow can change over time, and fissure systems can change during earthquakes (or by mineral deposition), geysers tend to change their patterns over time.

So where are the best geysers? The world's 'big four' geyser sites are Yellowstone, New Zealand, Kamchatka and Iceland. Our entire planet has less than 200 active geysers, and over half of these are in America's Yellowstone Park, which therefore has to be the top venue for geyser watching. But after that, comparisons are difficult. Each of the other three sites has its own special features, and visits to any or all of them are never wasted.

Yellowstone

The geothermal region within Wyoming's Yellowstone National Park has to be the most spectacular in the world. Most features lie within the

Fig. 2. Old Faithful creates a curtain of steam to catch the evening sun against a storm sky in America's Yellowstone Park.

barely recognizable rim of a volcanic caldera that last erupted 70 000 years ago. The park lays claim to over 100 active geysers, and although many of these are very small, its geyser suite is magnificent.

American-style publicity has made Old Faithful Geyser the best known in the world (Fig. 2). At about 40 m high, it's not the largest, nor is it the most awesome, but its water spout is classicly beautiful. Eruptions suit the visitor because they are both frequent and reliable, about every hour. The timing does vary between 45 and 100 min, but the next eruption time can be predicted on the basis of how long the previous eruption lasted; repeated observations have shown that longer eruptions are followed by longer intervals of quiet.

Old Faithful lies in the Upper Geyser Basin of the Firehole River valley, which has a remarkable collection of very large geysers. Smaller geysers erupt perhaps every 15 min, while the larger ones are all on cycles of less than 12 h. Among these is Castle Geyser, an oft-photographed classic because its water fountain emerges from a symmetrical cone of geyserite. Grand Geyser produces the largest eruptions in the Park (Fig. 3); up to 50 m high with multiple bursts from a multiple vent, its magnificent curtains of boiling water often appear at the same time as an eruption of the adjacent Turban Geyser. Even larger were Giant and Excelsior Geysers, but these now appear to be dead.

Outside the Upper Geyser Basin, Yellowstone has yet more geysers. Further down the Firehole River, Great Fountain Geyser erupts twice a day to a height of 40 m. Clepsydra is much smaller and a continuously active spouter, but the enormous Excelsior Geyser has only erupted once since 1888 (before when it was very active). Further north, Echinus is the largest geyser that erupts regularly in the Norris Basin, now that the 100-m-high eruptions of Steamboat Geyser have become rare and unpredictable. In the same basin, the more modest Porkchop Geyser went into extinction after a final violent explosion in 1989. While some of the Yellowstone geysers are clearly in decline, two small ones did start up after the nearby earthquake in 1959.

As backup to its many geyser basins, Yellowstone has the magnificent tufa terraces below Mammoth Hot Springs, boiling pools and hot springs galore, some distinctive steam fumaroles and some very fine boiling mud sites. It has no active volcanoes nearby, and cannot therefore offer good solfataras, but it does provide a unique experience in active geology; its popularity as a holiday destination is fully justified.

Iceland

With more than a dozen geothermal areas, and periodic activity on its volcanoes, Iceland has surprisingly few geysers. Haukadalur, a valley east of Reykjavik, contains the original Geysir. Its eruptions reached over 30 m high when they occurred every 30 min in the 1770s; but their interval increased to 20 days by the 1880s, and now it hasn't erupted naturally for years. It is well known that a geyser eruption can be started artificially by dropping soap into the vent. Tiny bubbles form more easily when surface tension

Fig. 3. Yellowstone's Grand Geyser erupts with pulsing jets of water that rise 50 m.

is reduced in the soapy water, and thereby initiate the boiling process, which, once started, builds up naturally into a healthy eruption. This technique was used to start up Geysir to suit tourist schedules, but the long-term effect has been to reduce the natural eruptions. Recognition that soaping is environmentally unfriendly came too late for Geysir, which remains unsoaped and inactive today. Its vent pool is 22 m deep and still full of water, which is at over 100 °C at the bottom, where it is prevented from boiling by the pressure.

Just 100 m from Geysir is Strokkur. It erupts about every 10 min and only reaches 15 m high, but it rates as the world's most fabulous geyser. This is because of its amazing eruptive style. The steam which starts the eruption emerges not as a few squirts and jets but as a single great expanding bubble. This can be seen rising through the perfectly clear water of the vent pool, and it rises to lift the pool surface into a hemispherical dome a few metres across. The dome lasts only for a few seconds before it bursts asunder and the geyser spout rises from within (Fig. 4). But for those few seconds it is a mesmerizing sight. Sadly, Strokkur has its own history of artificial interference. Visitors used to throw in clods of earth to constrict the vent and thereby increase the height of the subsequent eruption. The geyser was suffering, until it was revived by judicious drilling out of the vent at the bottom of the pool.

Iceland is the only one of the big four sites whose geysers are not in a recently active caldera. The island gains its geothermal heat from basaltic magma in the fissure systems of the Mid-Atlantic Ridge. Gryla is a geyser that daily erupts about 10 m high, in Gufudalur, 30 km south-west of Geysir, but the rest of the country has mainly fumaroles and solfataras. Notable are those at Namaskard and Laki, near Myvatn, where there is a splendid collection of mudpools. Iceland may not have many large and active geysers, but Strokkur is unique.

Fig. 4. The ascending sequence of three pictures shows the incomparable eruption of Strokkur, in south-east Iceland. The dome of water rises to a metre high before the steam bubble bursts through.

New Zealand

Rotorua must be the best known geothermal name after Yellowstone. Indeed, it is the centre of a great swathe of volcanic and geothermal activity that extends south to and beyond Taupo, in the middle of North Island. The lakes of both Rotorua and Taupo occupy calderas left from enormous prehistoric eruptions, and magma lies at shallow depths beneath a number of centres. The volcanoes are still active, but the geysers are in serious decline.

The Wairakei site (nearer to Taupo) had 70 active geysers where now there is none, for the suite of deep boreholes just to the south has been abstracting steam for the geothemal power station. Too much water, too much energy and too much steam have been taken from the ground, and the environment has been changed. Since the power scheme started in the 1950s, the Wairakei geyser eruptions have stopped and hot springs have diminished, but a new fumarole field has emerged at Craters of the Moon on the other side of the borehole field. Even the ground has subsided by 1.5 m in response to the reduced groundwater pressure, and there are many more subtle ways in which the geothermal features are declining under the invasive impact of humans.

Whakarewarewa is the only significant geyser site today. Right on the edge of Rotorua town, its splendid geothermal field of hot springs, geysers and mud pools wraps around the thermal village. Many families continue the Maori traditions of living on the hot ground, although they use the hot water less than did their ancestors. This fascinating urban setting distinguishes

Whaka (its easier, colloquial name) from the world's other wilderness geyser fields. In the heart of the Whaka field, there is a spectacular cluster of large geysers. Pohutu Geyser can erupt to 18 m high (always accompanied by its neighbour, the smaller Prince of Wales Feathers), but it has lost some of its glory in recent years; eruptions have become smaller, but last longer and are more frequent, so that it sometimes appears as a continuous spouter. The two largest geysers, Wairoa and Waikite, and the Papakura spouter have all ceased activity in the last 60 years, but there are some smaller geysers that survive on the site.

South of Rotorua, the Wai-O-Tapu geothermal field has some fine terraces and its fumarole activity continues to create dramatic collapse craters. Its sole geyser, Lady Knox, erupts every day at 10.15 a.m. (Fig. 5). This timing is not fortuitous; the geyser is started by a ranger dropping half a kilogram of soap flakes into its vent. A hundred years ago it was a hot pool; travellers stopped by to wash their clothes in it, and found that too much soap caused it to erupt. An iron pipe banged in the vent produced a higher geyser, and it became a tourist site. The pool and pipe are now covered by a geyserite cone (of silica and stearates), but its daily eruptions still reach about 15 m high.

The Rotomahana geyser field lay along a fissure line from the volcano of Mount Tarawera, until it was buried and destroyed in 1886 by the massive eruption of Tarawera. Also destroyed were the Pink and White Terraces, fabulous flights of geyserite ledges and hot pools, with a large active geyser at the top of the White Terraces. Often claimed as the world's finest terraces, they appear to have outshone Yellowstone's Mammoth Terraces (although comparisons with China's low-temperature Huanglong terraces are difficult). The original geysers and terraces now lie beneath Lake Rotomahana, but the fissure line continues into the Waimangu Valley, where a series of massive hot springs and lakes marks a geothermal field that became active only after the 1886 event. Within this, Echo Crater contains the site of Waimangu Geyser, which erupted to over 500 m high between 1900 and 1904 (Fig. 6). Its huge explosions of steam and mud were unpredictable, and one of them killed three tourists and their guide. In 1917 it again devastated the area with a shower of hot mud, but has not erupted since.

The ravages of Tarawera and mankind have both taken their toll; of the 200 active geysers in New Zealand 50 years ago, only 40 remain. But the modest assemblage of geysers is only a part of the very dramatic and active volcanicity on the North Island. As a bonus, the bubbling mud pools (at both Wai-O-Tapu and Whaka) are probably the finest anywhere.

Kamchatka

Remote on the east coast of Siberia, the Kamchatka peninsula lies on the Pacific Ring of Fire, and is consequently laced with active volcanoes and geothermal fields. Surrounded by the cones of explosive andesitic volcanoes, the Uzon caldera has had no volcanic eruptions for about 10 000 years, but it has a very active geothermal field, and includes *Dolina Geyserov*, the Valley of Geysers, just inside its eastern rim.

The valley of the Geysernaya River was only discovered by an itinerant geologist in 1941; it earned its name because it contains about 20

Fig. 5. (left) A scheduled, soap-induced eruption of Lady Knox Geyser features on the tourist trail around Rotorua, New Zealand.

Fig. 6. (right) A massive eruption of Waimangu Geyser a hundred years ago in New Zealand. The high water spout is blackened by its content of mud and rock debris. (Photo: Auckland Museum.)

significant geysers. It lies in a beautiful wilderness setting, and is only reached by helicopter and a short boardwalk system to its main geysers. Fountain Platform is claimed as the world's greatest concentration of geysers (Fig. 7). Its geyserite terrace is laced with a hundred or so steaming springs, fumaroles, spouters and geysers, but none produces a really large water fountain. Fountain Geyser is the largest, in almost continuous eruption to about 5 m high. As a geyser site it does not stand comparison with Yellowstone, but its mass of steam vents does create a remarkable sight. Either side of the Platform, the big three accessible geysers are Malyi, Bolshoi and Velikan (Little, Big and Giant) that erupt to heights of 8, 10 and 25 m (Fig. 8); true to form, their eruption intervals increase with their sizes, respectively, 35 and 75 minutes and 8 hours.

The central part of the Uzon caldera contains a profusion of hot springs, boiling pools, solfataras and mud volcanoes, but has no permanent geysers. Some of the geothermal pools have produced isolated eruptions to turn into short-lived geysers, and more may have gone unseen because the site has very few visitors. Elsewhere in Kamchatka, a host of geothermal areas have mainly hot springs, fumaroles and mud pools; the same applies to the caldera of Mutnovsky, but the flank of this volcano does have small geysers and spouters in its Dachnye basin.

For the 50 years of the Cold War, Kamchatka was closed to the outside world, and to most Russians. Now that it is open to visitors, its splendid volcanic and geothermal features are gaining the recognition that they deserve. With the recent decline of New Zealand's hydrothermal activity, Kamchatka's Dolina Geyserov could well be ranked as second best in the world for geysers, but both sites are just parts of exciting volcanic environments whose various features make comparisons difficult and unfair.

The rest of the world

There are plenty of geothermal fields around the world, but there are very few geysers outside the big four sites noted above. Chile, Japan, Tibet, Kenya, Indonesia, California (no longer active) and the Alaskan Aleutians have all reported geyser activity. El Tatio, in Chile, is perhaps the best known, but its activity is declining since geothermal power development has started nearby. Iceland apart, Europe is devoid of geysers; even Italy's Vulcano and Campi Flegri fields have only fumaroles, solfataras and mud pools. The Geysers geothermal power plant in California is named only after its steam plumes; the site has never had natural geysers.

While volcanic activity persists on our planet, we will always have geothermal regions, and some of these will contain geysers. But hot groundwater systems are fragile environments. So geysers come and go, and over the last century more have gone than have come. Eventually things will change, but now seems to be the time to plan a geyser-watching holiday.

Suggestions for further reading

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Tony Waltham is a geologist in Nottingham
tony@geophotos.co.uk

Fig. 7. (left) Fountain Geyser produces the far left steam plume in the cluster of geothermal vents on the Fountain Platform in Kamchatka's Valley of Geysers.

Fig. 8. (right) Visitors to the Kamchatkan wilderness watch an eruption of Malyi Geyser that sends water arcing out over the Geysernaya River.

Fig. 4. Morning steam clouds in El Tatio's main geyser basin.

Fig. 3. Trees were killed by the blast, with fine mud coating their foliage.

Geysers of El Tatio

Tony Waltham (Nottingham Trent University) writes In a past issue of *Geology Today* (v.16, no.3), the writer suggested that the world's four greatest geyser locations were Yellowstone, Iceland, New Zealand and Kamchatka. In that article, the El Tatio geyser field in Chile was rather churlishly dismissed as being just the best of the 'also-rans'. Since then, the site has been visited – and it really is rather splendid (Fig. 4).

El Tatio lies in the high Andes of northern Chile, about 100 km east of Calama, at an elevation of 4320 m. Its geysers and geothermal features are spread across the floor of a broad valley, overlooked by the ridge line of andesitic volcanoes that forms the border with Bolivia. The main geyser basin is about a kilometre long, less in width, with an adjacent, smaller, southern basin, and both have white floors that are a mixture of geyserite crusts and desiccated clays. The geothermal water is joined by a little snow-melt to form a small river that drains out to the west, and a few more hot springs and isolated geysers are strung down the outlet valley.

Claims that El Tatio has eighty or more geysers appear to flatter the site, because all the features are small; there are no tall geysers in the style of Old Faithful. Only a few reach heights of 1–2 m, and all the rest are less than a metre high. Furthermore, the flow rates are tiny at most vents, and there are only about a dozen that match the classic concept of erupting geysers. The rest could be more realistically described as fumaroles (though some do spurt out drops of water) or boiling pools.

The small southern basin has four good geysers with almost permanent fountains of water about a metre high with only slight fluctuations that could be

Fig. 5. One of the small geysers in almost permanent eruption mode in El Tatio's southern basin.

Fig. 6. A pool in El Tatio's southern basin that contains both a small geyser with a normal water fountain and beyond it a foaming vent that is momentarily less active.

Fig. 7. A small geyser on top of a 1.5 m-high geyserite dome in El Tatio's main basin, with an old drill rig and the steam plumes from the southern basin visible beyond.

called eruption cycles. An unusual feature is the foaming (Fig. 5) of some of the emerging water – very similar to the foaming on cold geysers that are driven by carbon dioxide (see *Geology Today*, v.17, no.1) – but the foam vents do emit steam and are in the same pools as normal, hot, non-foaming water spouts (Fig. 6). There are also a few large boiling pools and some lovely, temperature-controlled algal colouring in the outlet streams.

The main basin has fewer large features, but does have a great number of fumaroles and tiny spouters. Among these, a few modest geysers with more cyclical activity stand on top of siliceous geyserite domes (Fig. 7). There is also a zone of clean geyserite terraces. A few rusting old rusting drill rigs and capped boreholes are all that remains from fruitless attempts to harness the geothermal energy at this remote site. Some of the El Tatio geysers were reported to erupt to 6 m high before drilling disturbed the hot water circulation – apparently on a permanent basis.

Totally unfounded rumours that El Tatio's geysers are only active in the morning derive from the spectacular steam clouds that are only present in the cold morning air. An afternoon visit finds clearly visible, steam-free geysers in the southern basin, and almost no signs of activity in the main basino. But the place is transformed at dawn, with more than a hundred steam plumes rising into freezing cold, crystal-clear air against deep blue skies (Fig. 8). It is a dramatic diurnal contrast, that appears to be emphasized by the thin air at high altitude as it is still not exactly warm during the steam-free afternoons. It also accounts for the hordes of dawn visitors (who leave in minibuses from San Pedro at 4 a.m.), while the site is usually deserted after about 10 a.m.

El Tatio does lack any of the tall fountaining geysers that distinguish geyser basins elsewhere; and larger numbers of little geysers are no real substitute. However, its dawn display of steam plumes must rate as one of the world's greatest geothermal sights. It is unrealistic to make a complete ranking of the world's geyser basins, because it is almost impossible to equate highly variable features. With by far the largest number of the largest geysers, Yellowstone has to be the number one. But then it is only fair to say that El Tatio does belong in the second tier of geyser locations – alongside Iceland, New Zealand and Kamchatka – each different but each with its own special qualities.

Fig. 8. Early morning steam plumes rise from El Tatio's main basin.

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

Tony Waltham
Senior Lecturer in Engineering Geology, Civil Engineering Department, Nottingham Trent University

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.

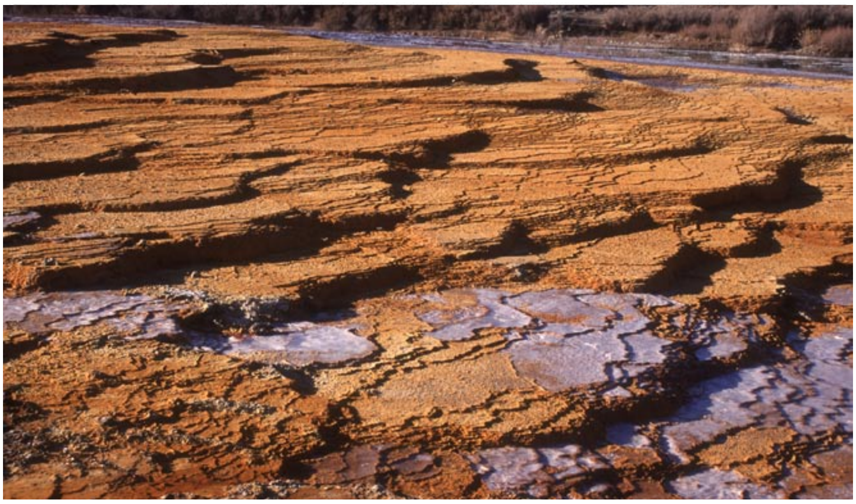

Fig. 5. Miniature terraces of travertine that extend away from Crystal Geyser, dry before an eruption.

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

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