

# Stories behind superlative scenery

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Rainforest of Wet Tropics of Queensland (Australia).

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Ngorongoro Conservation Area (United Republic of Tanzania) spans vast expanses of highland plains, savannah, savannah woodlands and forest.

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Ever since the adoption of the World Heritage Convention in 1972, superb natural landscapes have been the subject of particular care and concern. Among the ten criteria for World Heritage site inscription, the current criterion vii states that properties that ‘contain superlative natural phenomena or areas of exceptional natural beauty and aesthetic importance’ meet requirements that allow them to be considered for World Heritage listing. As of early 2012, there were 183 natural and 25 mixed sites, and as many as 131 of these have been inscribed under this criterion, often in conjunction with others. They include such iconic landscapes as the Great Barrier Reef in Australia, Huangshan in China, the West Norwegian Fjords, Serengeti National Park in the United Republic of Tanzania and Yellowstone National Park in the United States, to name just a few. Perhaps no one will question that these, and many others, are indeed extremely beautiful and scenic. And, surely, millions of visitors travelling every year to World Heritage properties are proof of a global consensus about what may be considered exceptionally scenic and memorable and thus worthy of a journey.

Yet criterion vii is steeped in paradox. The concept of natural beauty and aesthetic importance is intuitively the easiest to understand. Nor does communicating it to the general public require any special effort. In this respect, it differs from other criteria which emphasize much more specialized issues, such as ‘record of life’, ‘on-going ecological processes’, or ‘biological diversity’, to cite the language of the Convention. But at the same time, natural beauty is not all that easy to assess in an objective way that would also permit worldwide comparisons. What is it that really makes natural phenomena ‘superlative’? Such scenic natural landscapes can be visited around the world and may extend over thousands of kilometres (as do scenic coastlines, for example), but which of these are *exceptionally* scenic? The concept of aesthetics is no easier to deal with, being additionally affected by cultural differences.

### What makes landscapes superlative?

Approaching the problem from a personal perspective, there are probably hundreds of reasons why any one of us considers certain landscapes superlative. But in the context of the World Heritage Convention two main points emerge.

Living nature, endowed with ancient undisturbed forests, pristine grasslands, herds of freely roaming animals, bird and fish sanctuaries, is a recurrent theme of many properties inscribed under criterion vii. There are World Heritage sites in rainforests (Wet Tropics of Queensland, Australia), boreal forests (Virgin Komi Forests, Russian Federation), savannahs (Ngorongoro Conservation Area, Tanzania), inland wetlands (Pantanal Conservation Area, Brazil) and deltas (Danube Delta, Romania).

The second common theme is the physical landscape, that is, the combination of individual landforms. What are landforms? The answer is best provided by examples. River canyons, floodplains, waterfall steps, mountains, upstanding rock formations, caves, coastal cliffs and sea stacks are all landforms, created by natural processes which have relentlessly been shaping the surface of the Earth since its formation. Another component of physical landscapes is water. Hence springs, rivers, lakes, marshes, lagoons and an open sea are all landscape elements, as important as the landforms themselves. In fact it is water that directly creates many landforms, by freezing and turning into ice. Thus glaciers, ice caps and ice sheets add value to the physical landscape.

Natural physical landscapes compose practically the entire surface of the planet, except for some heavily urbanized or mining-modified terrains. But which landscapes represent the Outstanding Universal Value at the heart of the World Heritage Convention? We can approach the question by looking at numbers. The highest waterfalls, the longest glaciers, the deepest canyons, the largest concentrations of specific features, potentially fulfil the requirements. Thus, the presence of Angel waterfall, the highest on Earth, is emphasized in the statement of universal value for Canaima National Park (Bolivarian Republic of Venezuela), while Sagarmatha National Park (Nepal) has Mount Everest within its boundaries. Lake Baikal has been inscribed because it is the oldest and deepest lake in the world. We need to look at nature more broadly, though, as the World Heritage List should not be confused with the *Guinness Book of Records*. Rather than focusing on 'top' phenomena, we

see the Outstanding Universal Value in landscapes of extreme diversity – such as Te Wahipounamu – South West New Zealand, where there are mighty mountains, active glaciers, deep valleys, spectacular fjords, undisturbed temperate rainforest and rough seas. High mountainous relief, often with snow-capped summits, is another type of landscape that we tend to regard as exceptionally scenic, even though it may be harsh and hostile. Certain landscapes, carved into various types of rock, show astounding contrasts of colour which arouses admiration. This is why the Grand Canyon never fails to inspire, its sheer size and depth notwithstanding. Stark contrast of red and white sandstone adds to the scenic beauty of Wadi Rum Protected Area (Jordan), whereas coexistence of high cliffs of red rock and evergreen forest underpins the scenic beauty of China Danxia. Unusually shaped rock formations, essentially unique in the world, such as unbelievably sharp limestone pinnacles in Tsingy de Bemaraha

Strict Nature Reserve (Madagascar) or sandstone domes in Purnululu National Park (northern Australia), are further examples of what we consider as Outstanding Universal Value.

### Geomorphology – the science of scenery

Many visitors to World Heritage sites come simply to admire the beauty of the natural scenery and do not expect more than that. But just as many start asking an apparently simple question – why? Why does such unique, breathtaking scenery appear in this place rather than in any other? Why not closer to my own hometown? What forces of creation are behind the impossibly high mountains, deep river gorges, endless dunes, tortuous sea cliffs and bizarre rock pinnacles? The science of geomorphology has the answer, or at very least, it attempts to provide it.

Geomorphology is part of Earth Sciences and is best described as the scientific study



Angel waterfall in Canaima National Park (Bolivarian Republic of Venezuela) is the highest on Earth.

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Laguna Arhuaycocha at Huascarán National Park (Peru).

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of landforms, their assemblages, and the processes that moulded them in the past and that continue to change them today. Geomorphologists study the shapes of landforms and the regularities of their spatial distribution; they decipher their origin and evolution, and try to establish their ages. Geomorphology has also been dubbed the 'science of scenery'. Thus, the scenery – the combination of landforms and water – has become a subject of scientific inquiry. This is because each landscape tells a story and unravels pages from the history of the Earth. Where an untrained eye sees mainly the beauty of a physical landscape, geomorphologists go a step further, trying to answer questions about how and why and when such natural beauty came into being. Thus, geomorphology is also about the interpretation of natural landscapes and, in the context of World Heritage properties, it helps us to understand what brought about their uniqueness and their rarity. As geomorphologists, we study the natural scenery in the hope that better scientific understanding, far from depriving the world's iconic landscapes of their magic, may help us to appreciate their beauty even more.

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What does the science of geomorphology teach? First, processes that shape the surface of the Earth are universal and governed by basic principles of physics and chemistry. This may seem counterintuitive, since we see such an enormous variety of landforms and landscapes. But here comes the second key message, that these processes are controlled by a multitude of factors, such as rock type, air and ground temperature, amount of rainfall, type of vegetation, inclination of slope and many more. Thus, while the underlying principles are universal, there may be endless combinations of factors behind landscape evolution in any given place. And this explains why some landscapes are unique by global standards or display certain features in an exceptional manner. Geomorphology also teaches that landscapes vary by age. We have very

ancient and very young scenery on Earth. For example, the geomorphological history of Uluru inselberg (rock hill rising out of a plain) in Australia can be traced back to the Mesozoic era, more than 65 million years ago. By contrast, most high mountains acquired their shape during the last Ice Age that ended a mere 10,000 years ago. Some landscapes can be dynamically evolving while others are rather quiet and apparently dormant. Thus, we have the 'living' physical landscape of Yellowstone with its geysers and other hydrothermal phenomena, or Peru's Huascarán National Park, famous (or rather infamous) for its deadly rock avalanches on the one hand and, on the other, Russia's majestic Putorana Plateau, a testament of vigorous volcanism that occurred some 250 million years ago. Each landscape tells a story and it is now time to review a few of them in more detail.



Waterfalls at Iguazu National Park (Argentina / Brazil).

© Jimmy Harris

## Stories behind landscapes

### In the land of fairy chimneys

When it comes to illustrating the phrase ‘improbable landscapes’, few places in the world can rival Cappadocia in central Turkey. At the heart of this region is the World Heritage property of Göreme National Park and the Rock Sites of Cappadocia, inscribed in 1985. This is a mixed site, with unique and diverse cultural heritage, reflected in the application of three criteria for cultural properties, but it is mostly the scenery that attracts our attention. Cappadocia’s landmarks are pointed pinnacles that assume a large spectrum of shapes, from regular cones through needles to columns capped by big boulders. Individual pinnacles are not necessarily very tall, 10–15 m is the usual height, but it is the large number of them distributed over a relatively small area that makes Cappadocia special. In addition to pinnacles, there is a dense network of gorges and gullies, whose steep sides contrast with flat interfluves. In a few places isolated rock hills stand out, their slopes hollowed out for very practical purposes by generations of people living here – to built living rooms, storage rooms, vantage

points, dovescots, and last but not least, the rock-hewn churches for which Cappadocia is famous. What is the story behind this particular scenery? All this started a few million years ago, when central Anatolia was the scene of powerful volcanic activity. A basin lay to the north of the volcanic chain, which was gradually filled with the products of volcanic eruptions: ash, scoria, volcanic bombs and occasional lava flows. Together with sediments of a lake that was temporarily present in the basin, they eventually formed a thick package of layers of different origin and degrees of resistance. Subsequent uplift of the basin triggered erosion accomplished by streams, leading to the dense gully network we see today. Another key process here was weathering: the natural breakdown of rock into smaller pieces. This occurs everywhere, but here it achieved spectacular results because of the unequal resistance of different rock layers and climatic conditions. Considerable temperature and humidity changes between day and night and between seasons contribute to the greater efficacy of weathering and to the origin of ‘fairy chimneys’, as the pinnacles of Cappadocia are known in popular literature.

### Mighty waterfalls

Waterfalls are among the most awesome and inspiring of natural geomorphological phenomena. Huge cascades of water tumbling down the steep cliffs, roaring through canyons that extend over many kilometres, often veiled in a drenching mist, offer a unique spectacle of nature. No wonder that vast numbers of tourists travel every year to see the most famous waterfalls on Earth such as Niagara, Victoria or Yosemite. But again, each one of these waterfalls has a story to tell. Take the Iguazu / Iguazu Falls as an example, located at the Argentinean / Brazilian border, which have been listed as World Heritage since 1984 (Argentina) and 1986 (Brazil), to include not only the falls but the surrounding rainforest. The falls themselves are nearly 3 km wide and 77 m high in the deepest place, known as Garganta do Diablo (Devil’s Throat), where water plunges into a huge cauldron. Why are the falls here and not somewhere else? The reasons lie in the history of rivers in this part of the continent, a history that reaches back for tens of millions of years. A general rule of river behaviour states that



The spectacular Wulingyuan Scenic and Historic Interest Area (China) with its rock columns.

© Piotr Migoń

the more water a river carries, the more efficiently it can cut down into bedrock. In consequence, a step often forms at a confluence of two rivers differing in mean discharge. In our example, the main river draining the area, the Paraná, was a much more potent agent of erosion than such tributaries as the Iguazu river, carrying less water. However, the two rivers meet not at the falls, but some 21 km downstream. Is this significant? Yes, it is. It shows that the falls receded from the site of confluence to their present position and there are good reasons to believe the scientists when they suggest a rate of waterfall retreat of 1.4 cm to 2.1 cm per year during the last 2 million years. The gorge that extends downstream from the falls is the legacy of this long-term recession. Geomorphology also helps us to understand the shape of the falls. The explanation of their staircase appearance, with a bench separating two steps, is to be sought in the underlying geology. The Iguazu river flows over an ancient lava terrain, a basaltic plateau. The plateau is actually built of a series of flows stacked one upon another, each a few tens of metres thick. The staircase reflects the occurrence of consecutive flows, with the steps developed upon the most massive portions of the lava. Thus,

### **Wulingyuan is a plateau built of a very thick sequence of sandstones, nearly 500 m high, elevated by tectonic forces and incised by numerous rivers.**

the Iguazu / Iguazu Falls are not only a site of supreme natural beauty, they are also one of the best examples in the world of the principles of bedrock river evolution.

#### **Is gravity working there?**

In the north-western corner of Hunan province in southern China a bizarre landscape occurs, inscribed in 1992 under the name of Wulingyuan Scenic and Historic Interest Area, but now better recognized as Zhangjiajie. What is so unusual about this site? Look at the pictures and you will immediately know the answer. The hundreds, maybe thousands of rock columns and pillars, rising from the dense subtropical forest to a height of 300 m or more, are an awesome sight. It is even more captivating when the forest below is draped in fog or mist and the rock columns appear to be floating in the sky. Indeed, this very motive was used in the popular movie *Avatar*, where the otherworldly film landscape was modelled on this scenery. Wulingyuan is a plateau built of a very thick

sequence of sandstones, nearly 500 m high, elevated by tectonic forces and incised by numerous rivers. Around the world many examples of dissected plateaux can be found, so this in itself is not so unusual. But instead of a network of canyons we have a 'forest of peaks' lining all valley sides and the margins of the plateau. Some columns are unbelievably slender and look like fragile building-block constructions on the verge of collapse, yet they stand proudly defying the force of gravity. What combination of factors brought this scenery into being? Many mysteries of Wulingyuan geomorphological landscape remain to be unravelled, but surely the little variation throughout the sandstone sequence plays a role (compare this with the stepped sides of the Grand Canyon). The very regular jointing, that is the network of natural discontinuities in rock, is another key factor and it is clear that smooth rock faces follow joint surfaces. Third, the local sandstone is quite a hard rock that can withstand significant stresses and stands firm, otherwise the columns



Sermeq Kujalleq at Ilulissat Icefjord (Denmark) is one of the most active glaciers in the world.

© Jean Pierre Margaix

## Behind the beauty of the calving ice front is a story of long-term glacial erosion, partly revealed in the geomorphology of the fjord.

would have collapsed long ago. The origin of Wulingyuan scenery continues to puzzle scientists and it is no surprise that the new research centre in Zhangjiajie has placed this issue very high on its agenda.

### At the junction of land, ice and water

Coasts tell fascinating stories. Interactions between waves, tides and currents on the one hand, and cliffs, beaches and mudflats on the other, produce spectacular scenery, much of which is included on the World Heritage List. But Ilulissat Icefjord in Greenland (Denmark), inscribed in 2004, adds another dimension – ice. The property is located on the western coast of this largest island on Earth, where the Sermeq Kujalleq glacier, an outlet glacier of the Greenland ice cap, reaches the sea, ending in a steep ice cliff. This is the place where the awesome phenomenon of calving (iceberg production) can be observed and it is estimated that the huge volume of more than 35 km<sup>3</sup> of ice is detached annually from the ice front and falls into the sea,

sometimes filling the entire fjord, which is nearly 50 km long. Behind the beauty of the calving ice front is a story of long-term glacial erosion, partly revealed in the geomorphology of the fjord. Scientists found that the tongue of Sermeq Kujalleq moves very fast, up to 19 m a day, which is one of the highest rates recorded on Earth. This is important because, generally speaking, the faster the ice movement, the greater impact is exerted on the bedrock. Fjords are thus products of prolonged deepening and widening of a pre-existing river valley by a fast-moving glacier or an ice stream and hence Ilulissat Icefjord, whose depth locally exceeds 1,000 m, is both the testament of past powerful glacial erosion as well as a natural laboratory to study this process as it occurs today. Looking at the glacier front and icebergs occupying the fjord we can imagine how the West Norwegian Fjords may have looked some 15,000 years ago. More importantly, we can understand the mechanisms by which they were formed.

### Future study

Beautiful geomorphic scenery underpins most World Heritage natural properties, whether they have been inscribed on the basis of criterion vii or other criteria. Many cultural sites are also located within spectacular natural landscapes. At the time of inscription the Outstanding Universal Value of their scenic qualities may have not been acknowledged, but this should not prevent us from appreciating them and trying to understand them.

The 'wow!' factor is important, and it may even be an appropriate test in making an initial assessment of a property, but there is much more behind it of course. Usually, the more awesome a landscape is, the more intriguing and complex is its natural history. Geomorphology is able to make a great contribution towards unravelling its secrets, enriching the experience of visitors, providing a solid basis for comparative analysis and guidelines for further development. Last but not least, it offers crucial advice touching upon the management of World Heritage properties which are inevitably affected by natural surface processes: weathering, landslides, floods, cliff collapses, ground subsidence and many more. Thus, research towards understanding the scenery is not only an academic exercise; it also has an important practical dimension. ☺