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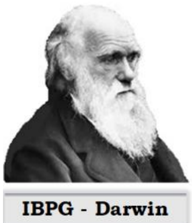

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Death Valley: exploring one of the most extreme landscapes on Earth

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ABSTRACT

This article presents a photographic and interpretative overview of a scientific and touristic expedition carried out in Death Valley National Park, one of the most extreme desert environments on Earth. Located primarily in California, with portions extending into Nevada, Death Valley is internationally known for recording some of the highest temperatures ever measured, as well as for its striking geological contrasts and long-term environmental history. Based on field observations conducted in May 2016, this work integrates visual documentation with a descriptive analysis of the region's physical geography, geological evolution, climate, ecosystems, and patterns of human occupation. Particular attention is given to the ways in which tectonics, arid climate, and sedimentary processes interact to shape the landscape, as well as to the remarkable biological and cultural adaptations that enable life to persist under extreme conditions. By combining scientific interpretation with photographic records obtained during the expedition, the article seeks to contribute to a broader understanding of Death Valley as both a natural laboratory for desert studies and a landscape of ecological, historical, and touristic significance.

***Keywords*:** Death Valley, Ecotourism, Desert Geology, Arid Climate, Ecosystems Adaptation

INTRODUCTION

The national parks of the United States form a highly structured and integrated system designed to protect natural landscapes of significant ecological, geological, and cultural value, while also ensuring orderly public access. These parks are distinguished by the diversity and grandeur of their scenic beauty, encompassing mountains, deserts, forests, coastal areas, and river systems, often preserved in a near-natural state.

The system is characterized by careful planning, well-distributed infrastructure, visitor centers with a strong educational focus, clearly marked trails, and well-defined conservation policies. Management efforts aim to balance environmental protection, scientific research, tourism, and education, contributing to the preservation of fragile ecosystems and the appreciation of natural heritage.

Overall, U.S. national parks are internationally recognized as exemplary models of large-scale conservation, successfully combining environmental protection, aesthetic experience, and responsible public use.

This article presents the results of a scientific and touristic expedition conducted in May 2016 in Death Valley National Park (Figure 1). Field activities combined direct observation, photographic documentation, and on-site interpretation of geological and geomorphological features under extreme environmental conditions. High temperatures, strong solar radiation, and limited accessibility influenced both the duration of fieldwork and the selection of observation points.

The expedition sought not only to document representative landscapes, but also to relate visual records to broader geological, ecological, and historical processes that shape Death Valley as a complex desert system.

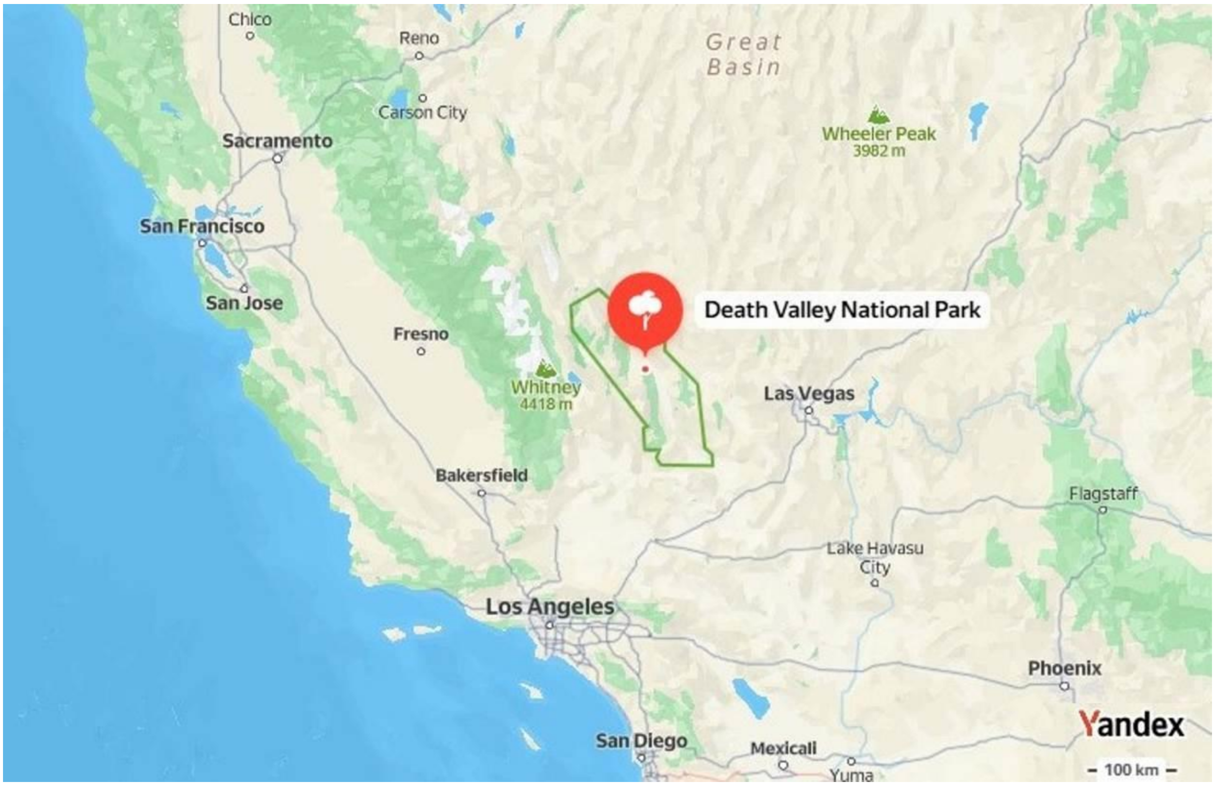

Figure 1. Location of Death Valley National Park in California, USA. http://maps.yandex.com

Location and Physical Geography

Death Valley is situated in the southwestern United States, extending along the boundary between California and Nevada (**Photos 1-7, 73-76**). From a geomorphological standpoint, the region forms part of the Basin and Range physiographic province, a vast tectonic domain characterized by elongated valleys alternating with roughly parallel mountain ranges produced by crustal extension.

The valley measures approximately 225 km in length and varies from about 8 to 24 km in width. One of its most striking features is the presence of the lowest elevation in North America: Badwater Basin, located roughly 86 meters below mean sea level. This extreme depression is set in sharp contrast with nearby high-relief terrain; less than 150 km to the west rises Mount Whitney, which, at 4,421 meters, constitutes the highest point in the contiguous United States. This juxtaposition illustrates the exceptional vertical relief that defines the region.

The physical landscape of Death Valley is shaped by extensive salt flats, broad alluvial fans, deeply incised canyons, and prominent mountain ranges, notably the Panamint Range and the Amargosa Range. The interaction of these elements produces a dramatic and visually distinctive desert environment, where tectonic structure and surface processes are clearly expressed (**Photos 8-70**)

The Panamint Range and the Amargosa Range form the principal mountain systems flanking Death Valley and exert a decisive influence on its geographic, climatic, and geological configuration. The Panamint Range, located along the western margin of the valley, reaches elevations exceeding 3,300 meters, with peaks such as Telescope Peak standing in pronounced topographic contrast to the floor of Badwater Basin [1]. Along the eastern margin, the Amargosa Range displays lower overall elevations but considerable geological complexity. Both ranges originated through tectonic processes associated with crustal extension in the Basin and Range province, where normal faulting led to the uplift of mountain blocks and the subsidence of the central valley. Beyond defining the relief, these mountain barriers strongly affect the local climate by limiting the inflow of moisture, thereby intensifying arid conditions. At the same time, erosion of the surrounding highlands supplies sediments that feed alluvial fans and contribute to the development of the valley's salt flats.

Geological Origin

The geological evolution of Death Valley spans hundreds of millions of years and reflects a long history of tectonic instability. The oldest rocks exposed in the region date to the Precambrian and exceed 1.7 billion years in age. Over geological time, the area has been affected by multiple tectonic regimes, including subduction-related processes, episodes of volcanism, and widespread faulting.

To illustrate the relative scale of this history, one may consider Earth's estimated age of approximately 4.6 billion years compressed into a single calendar year. In this analogy, planetary formation would occur in the first minute of January 1, while the formation of the oldest rocks in Death Valley would correspond to around August 18, at approximately 2:24 a.m. By contrast, the emergence of *Homo sapiens* would take place only on December 31, near 11:37 p.m. This comparison underscores how recent human history is when viewed against deep geological time, despite the disproportionate impact human activity has had on landscapes and ecosystems.

The current geomorphological configuration of Death Valley began to develop approximately 16 million years ago, during a phase of regional crustal extension associated with the Basin and Range province [2]. This tectonic regime produced a characteristic pattern of alternating uplifted and subsided crustal blocks, commonly described as a horst–graben system [3].

In this context, horsts correspond to relatively elevated fault-bounded blocks that form mountain ranges, whereas grabens represent down-dropped blocks that evolve into sedimentary basins. Continued extensional stress generates a stepped topography, in which sharp vertical relief contrasts are preserved over geological timescales. Death Valley offers one of the clearest surface expressions of this structural arrangement, allowing direct observation of the relationship between faulting, relief generation, and sediment accumulation [4, 5].

Volcanism and Sedimentation

Volcanic activity played an important role in shaping the region, particularly between approximately 12 and 4 million years ago. Remnants of this activity are preserved in the form of lava flows, volcanic ash layers, and rhyolitic domes, which can be observed in several areas of the park and provide evidence of an active volcanic past.

Sedimentary processes were equally influential in molding the valley. During wetter intervals of the Pleistocene, extensive lakes occupied the valley floor, the largest of which was ancient Lake Manly. As climatic conditions gradually became more arid, these lakes evaporated, leaving behind thick accumulations of evaporite minerals that now form the extensive salt flats characteristic of the valley.

Lake Manly was a large freshwater body that filled Death Valley during glacial periods of the Pleistocene, when regional climatic conditions were cooler and wetter than today. Supplied by rivers draining the surrounding mountain ranges, including the Panamint and Amargosa ranges, the lake reached depths of up to approximately 180 meters and extended for more than 150 km along the valley. With the retreat of glacial conditions and the onset of increased aridity during the Holocene, the lake gradually evaporated. Its legacy is preserved in thick sequences of lacustrine sediments and evaporitic salts that today form the Badwater Basin salt flats [6]. These deposits are of particular importance for reconstructing the paleoclimate of the southwestern United States and for understanding the long-term environmental evolution of Death Valley.

Badwater Basin

Badwater Basin is one of the most emblematic locations within Death Valley National Park and represents the lowest topographic point in North America, situated approximately 86 meters below mean sea level [7]. It is located in the central-eastern portion of the valley, at the base of the Amargosa Range. The name “Badwater” refers to the poor quality of the limited surface water found in the area, whose extremely high salinity renders it unsuitable for human consumption (**Photos 53-60**).

The landscape of Badwater Basin is dominated by extensive salt flats that cover tens of square kilometers and display a distinctive white surface marked by polygonal patterns. These geometric forms are among the most visually striking features of the basin and reflect active surface processes rather than static conditions.

From a geological perspective, Badwater Basin is a tectonic depression formed by normal faulting associated with crustal extension within the Basin and Range province. Continued subsidence of the valley floor, combined with uplift of the surrounding mountain ranges, has promoted the accumulation of fine-grained sediments and thick deposits of evaporite minerals.

During the Pleistocene, the basin was occupied by Lake Manly, a freshwater lake that reached depths of up to approximately 180 meters. As regional climate conditions became progressively drier throughout the Holocene, the lake gradually evaporated, leaving behind substantial deposits of halite ($NaCl$), gypsum ($CaSO_4 \cdot 2H_2O$), and other evaporitic minerals. These salts crystallize at the surface, forming polygonal crusts produced by repeated cycles of dissolution, evaporation, and recrystallization.

Despite its appearance of extreme dryness, Badwater Basin maintains a limited but active hydrological system. Small amounts of groundwater emerge through shallow springs, dissolving salts and redistributing them across the basin floor. Intense evaporation rapidly concentrates dissolved ions, resulting in salinity levels that often exceed those of seawater.

Geochemical analyses indicate that the salts present in Badwater Basin reflect both the composition of the surrounding bedrock and atmospheric inputs, such as aerosol deposition. In this sense, the basin functions as a natural archive of interactions among climate, geology, and hydrology in hyper-arid environments.

Badwater Basin is therefore a key site for scientific research in several fields: desert geomorphology, particularly the study of evaporitic plains; paleoclimatology, through the analysis of ancient lacustrine sediments; astrobiology, as extreme saline environments are considered analogues for conditions on Mars and icy moons; and tectonic dynamics, given the ongoing activity of regional fault systems. Although the salt flat may appear stable, it is continuously evolving on geological timescales, making it an exceptional natural laboratory.

Although Badwater Basin is often perceived as a static and lifeless environment, field observation reveals an active and continuously evolving system. Subtle changes in surface texture, moisture distribution, and salt polygon morphology indicate that even minimal hydrological inputs can reorganize the basin floor. This dynamism underscores the sensitivity of evaporitic landscapes to climatic variability and highlights the importance of long-term monitoring in hyper-arid environments.

Life in Badwater Basin

Biological life in Badwater Basin is extremely limited but not entirely absent. Halophilic microorganisms are able to survive within thin, moisture-rich layers of the salt crust. Near small freshwater springs and shallow channels, the Death Valley pupfish (*Cyprinodon salinus*) occurs, representing one of the most remarkable examples of vertebrate adaptation to extreme environmental conditions [8].

Cyprinodon salinus inhabits small springs, shallow streams, and brackish to hypersaline waters characterized by intermittent flow. These habitats are frequently isolated from one another, a condition that has promoted genetic differentiation among populations. The species is notable for its ability to survive conditions that would be lethal to most fish, including water temperatures exceeding 40 °C, salinity levels equal to or greater than seawater, low concentrations of dissolved oxygen, and rapid environmental fluctuations.

These adaptations are supported by advanced physiological mechanisms of osmoregulation, efficient metabolic processes, and adaptive behavioral strategies. The species is small in size, typically measuring between 5 and 8 cm, has a relatively robust body form, and exhibits variable coloration, with males often displaying brighter hues. Its diet consists primarily of algae, organic detritus, and small invertebrates, and it reproduces rapidly, with short life cycles that are advantageous in unstable environments [9].

Because of these characteristics, *Cyprinodon salinus* is widely regarded as a model organism for studies of evolution in isolated systems, physiological adaptation to extreme environments, conservation of endemic species, and astrobiology, particularly in the context of life under conditions analogous to extraterrestrial environments. Despite its resilience, the species is considered vulnerable due to its dependence on highly restricted habitats. Major threats include alterations to hydrological regimes, climate change, the introduction of invasive species, and indirect impacts from tourism. Consequently, *Cyprinodon salinus* is protected under United States environmental legislation, and its populations are closely monitored.

The Salt of the Badwater Basin

In practical terms, the salt deposits of Badwater Basin are neither edible nor suitable for human consumption and are not commercially exploited today. This assessment is based on chemical composition, sanitary considerations, historical factors, and legal restrictions.

Chemically, the salt crust of Badwater Basin is not composed of pure sodium chloride. Instead, it consists of a complex mixture of evaporitic minerals, including halite ($NaCl$), gypsum ($CaSO_4 \cdot 2H_2O$), anhydrite ($CaSO_4$), and trace amounts of borates, carbonates, magnesium, potassium, and other elements. This heterogeneous composition produces a bitter or metallic taste and may pose health risks if certain minerals are ingested in elevated concentrations. Furthermore, the salt is exposed to dust, microorganisms, and naturally occurring contaminants and undergoes no processes of refinement, purification, or iodization. For these reasons, it is neither safe nor recommended for human consumption.

There has been no significant commercial extraction of salt from Badwater Basin for several reasons. Deposits of purer and more accessible salt exist elsewhere in the United States, making extraction in Death Valley economically uncompetitive. In addition, the mixed mineral composition reduces commercial value. Historically, mining activities in the region focused primarily on borates rather than salt, particularly during the late nineteenth and early twentieth centuries, when the famous Twenty Mule Teams transported borax across the desert [10]. Finally, the establishment of Death Valley National Park placed the area under strict environmental protection, prohibiting mineral extraction.

Historical evidence suggests that Indigenous groups, particularly the Timbisha Shoshone, made limited use of natural salts for medicinal, ritual, or minor preservation purposes. Such use was small-scale and based on traditional knowledge rather than systematic exploitation.

Tourism at Badwater Basin

From a tourism perspective, Badwater Basin is one of the most frequently visited locations within Death Valley National Park. To minimize environmental impact while allowing public access, a wooden boardwalk has been installed, enabling visitors to walk across the salt flats without damaging the fragile crystalline surface. Interpretive panels along the trail provide information on the geological formation of the basin, its climatic conditions, and its scientific relevance.

On clear days, the site offers a striking visual contrast between the valley floor and the surrounding mountain ranges. The Panamint Range, rising to elevations exceeding 3,300 meters, dominates the western horizon, emphasizing the extreme vertical relief characteristic of the Basin and Range province. This dramatic juxtaposition between the lowest point in North America and some of its highest desert mountains makes Badwater Basin particularly attractive for landscape photography, short walks, and informal geological observation.

Park authorities consistently warn visitors about the risks posed by extreme temperatures, especially during summer months, when ground surface temperatures may exceed 70 °C. For safety reasons, visits are strongly recommended during the early morning or late afternoon. The use of sun protection, appropriate clothing, and sufficient hydration is essential, even for brief excursions.

Badwater Basin is a legally protected area, and activities such as salt collection, off-trail walking, or any disturbance of the surface are strictly prohibited. These regulations play a fundamental role in preserving the basin’s geomorphological features and ecological integrity, ensuring that both scientific research and tourism can coexist without compromising this unique environment.

Comparative Perspective: Badwater Basin, the Dead Sea, and Lake Assal

Badwater Basin can be compared to other regions of the world that also lie below mean sea level, most notably the Dead Sea in the Middle East and Lake Assal in Djibouti. While these environments share a similar topographic characteristic, they differ substantially in geological origin, hydrology, salinity, and patterns of human use.

Badwater Basin (United States) is located at approximately –86 meters relative to sea level. It is a continental evaporitic plain formed within a tectonic depression associated with crustal extension in the Basin and Range province. Its hydrology is dominated by ephemeral surface water and shallow groundwater, with no connection to the ocean. Salinity levels are high, with surface deposits composed mainly of halite and sulfates. Human use is restricted to controlled tourism and scientific research. The basin represents a highly dynamic system in which evaporation greatly exceeds water input, resulting in salt crusts that are continuously dissolved and reformed.

The Dead Sea (Israel/Jordan) lies at approximately –430 meters and represents the lowest exposed continental surface on Earth. It is a permanent, closed hypersaline lake formed along the transform fault system of the Jordan Rift Valley. The lake is primarily fed by the Jordan River and has an exceptionally high salinity, averaging around 340 g/L, dominated by magnesium, potassium, and bromide ions. Human use includes intensive tourism, mineral extraction, and therapeutic applications. Unlike Badwater Basin, the Dead Sea is a persistent water body, although it is undergoing rapid shrinkage due to regional water diversion. Its unique chemistry prevents the survival of fish and higher aquatic plants.

Lake Assal (Djibouti) is situated at approximately –155 meters and constitutes a continental saline lake associated with the active tectonics of the Afar Rift and recent volcanic activity. The lake is fed by groundwater and occasional marine incursions through fractures connected to the Red Sea. Its salinity is comparable to, or even higher than, that of the Dead Sea. Human activities include traditional salt extraction and geological research. Lake Assal represents a rare combination of active rifting, volcanism, and extreme salinity, making it an important natural laboratory for studying continental crustal processes.

Although all three environments lie below sea level, their differences reflect distinct geodynamic contexts. Badwater Basin is best described as a predominantly seasonal and evaporitic system, whereas the Dead Sea and Lake Assal are permanent hypersaline lakes. From a scientific perspective, comparing these sites enhances understanding of the interactions among tectonics, arid climate, hydrological balance, and the evolution of extreme landscapes. From a tourism standpoint, each location offers a unique experience, ranging from geological observation in Death Valley to therapeutic and recreational activities at the Dead Sea.

General Characteristics of Death Valley

Death Valley is characterized by an extreme desert climate, classified as BWh under the Köppen system, and is widely recognized as one of the hottest and driest regions on Earth. The highest air temperature ever officially recorded on the planet, 56.7 °C, was measured at Furnace Creek on July 10, 1913. During summer, daytime temperatures frequently exceed 45 °C, while winter nights can be relatively cold, particularly at higher elevations.

Average annual precipitation in much of the valley is less than 60 mm, and some years experience virtually no rainfall. When precipitation does occur, it is often associated with isolated convective storms or the remnants of Pacific hurricanes. Such events may trigger flash floods, which play a significant role in shaping the valley's geomorphology despite their rarity.

Frequent winds contribute to erosion and sediment transport, leading to the formation of extensive dune systems, such as the Mesquite Flat Sand Dunes (**Photos 61-63**). These aeolian processes interact with fluvial activity to redistribute sediments across the valley floor.

Despite the arid conditions, Death Valley possesses a complex hydrological system. Most surface water is ephemeral, resulting from sporadic rainfall events. Temporary streams carve canyons and feed alluvial fans along the margins of the valley. In addition, deep groundwater aquifers sustain small springs and oases, such as those at Furnace Creek and Scotty's Castle. These water sources are essential for the survival of local flora and fauna and have historically played a central role in human occupation of the region.

Flora and Fauna of Death Valley

The vegetation of Death Valley is remarkably adapted to extreme water scarcity and persistently high temperatures. Many plant species exhibit deep root systems, reduced or waxy leaves, and short life cycles, allowing them to survive prolonged droughts and exploit brief periods of moisture availability (**Photos 48, 71, 72)**.

Among the most common plant species are the creosote bush (*Larrea tridentata*), various cacti, halophytic shrubs in saline environments, and annual plants that germinate rapidly following rare rainfall events [11]. These annuals complete their life cycles within weeks, producing seeds capable of remaining dormant for extended periods.

Larrea tridentata is the most widespread plant across large portions of Death Valley, particularly on alluvial plains, rocky and nutrient-poor soils, and low-elevation areas characterized by extreme aridity. It functions as a keystone species, structuring desert ecosystems by regulating plant spacing, influencing soil dynamics, and shaping the distribution of other plant and animal species. The removal of *Larrea tridentata* would significantly reduce ecosystem stability across much of the desert [12, 13].

For Indigenous peoples of the southwestern United States, including groups culturally related to the Timbisha Shoshone, *Larrea tridentata* held important medicinal, ritual, and practical uses, such as natural antiseptics and infusions. Its distinctive scent after rainfall is commonly associated with the phenomenon known as "desert rain," which holds strong cultural significance. Numerous organisms depend directly or indirectly on this shrub, including pollinating insects, lizards, small reptiles, rodents, and birds that use it for shelter. Although the plant is toxic and not widely consumed, it plays a crucial role in local food webs.

Ecologically, *Larrea tridentata* stabilizes soils, reducing erosion and dust generation, and creates so-called "fertility islands" beneath its canopy, where organic matter and nutrients accumulate. These microhabitats provide shade and thermal refuge for insects, reptiles, and small mammals and are essential for maintaining biodiversity in hyper-arid environments such as Death Valley [14].

Despite its extreme climate, Death Valley supports a surprisingly diverse fauna. This diversity is made possible by a combination of physiological, behavioral, and ecological adaptations, as well as the presence of altitudinal gradients, springs, and localized microhabitats [15].

More than 50 species of mammals have been recorded in the park, most of which are nocturnal. One of the most emblematic species is the desert bighorn sheep (*Ovis canadensis nelsoni*) [16, 17], a symbolic species of the park that inhabits steep mountainous terrain and depends heavily on reliable water sources.

The coyote (*Canis latrans*) is a highly adaptable predator widely distributed throughout Death Valley [18]. The term "coyote" originates from the Nahuatl language. Sometimes referred to as the "American jackal" in zoological literature, *Canis latrans* belongs to the canid family and ranges from Alaska to Panama.

Another canid species present is the kit fox (*Vulpes macrotis*), which is characterized by large ears measuring between 70 and 95 mm that enhance heat dissipation and auditory sensitivity. The species is primarily nocturnal. The cougar (*Puma concolor*) represents the apex predator of the region and is rarely observed, being largely restricted to mountainous areas. This species has the broadest geographic distribution of any terrestrial mammal in the Western Hemisphere, historically ranging from British Columbia to southern Chile.

Among small mammals, notable species include the desert kangaroo rat (*Dipodomys deserti*) [19], the cactus mouse (*Peromyscus eremicus*) [20], and the black-tailed jackrabbit (*Lepus californicus*) [21]. These animals survive with minimal intake of free water, obtaining moisture from food and metabolic processes.

Reptiles are among the groups best adapted to the harsh climate of Death Valley. Well-known species include the leopard lizard (*Gambelia wislizenii*) [22], the fringe-toed lizard (*Uma scoparia*) [23], the chuckwalla (*Sauromalus ater*) [24], the Mojave rattlesnake (*Crotalus scutulatus*) [25], the western diamondback rattlesnake (*Crotalus atrox*) [26], and the California kingsnake (*Lampropeltis californiae*) [27]. These reptiles regulate body temperature primarily through behavior, avoiding surface activity during the hottest hours of the day.

More than 300 bird species have been recorded in Death Valley, many of them migratory. Common resident species include the American crow (*Corvus brachyrhynchos*) [28], the burrowing owl (*Athene cunicularia*) [29], and the golden eagle (*Aquila chrysaetos*) [30]. Birds associated with water sources and oases include the great egret (*Ardea alba*) and several migratory duck species of the genus *Anas*, which depend heavily on springs, temporary wetlands, and higher-elevation habitats.

Invertebrates constitute the most numerous, though least conspicuous, animal group in Death Valley. Among arachnids, desert scorpions (*Hottentotta* spp.) [31] are notable, while common insects include desert harvester ants (*Pogonomyrmex* spp.) [32] and darkling beetles (*Eleodes* spp.) [33]. These arthropods are typically nocturnal, possess cuticles resistant to water loss, and exhibit specialized behaviors to avoid extreme heat, such as rapid, direct movement and the construction of deep burrows with stable temperatures.

Harvester ants of the genus *Pogonomyrmex* play an important ecological role through seed collection and dispersal. While many collected seeds are consumed, others germinate, contributing to plant propagation. Their deep nests aerate the soil, improve water infiltration, and redistribute nutrients, creating localized zones of increased fertility. As such, these ants serve as valuable bioindicators, with their presence or absence reflecting environmental change, habitat degradation, or climatic stress.

Overall, the fauna of Death Valley represents a biological threshold of animal life and a natural laboratory for studies in evolution, extreme physiology, and climate change. Far from being an empty desert, Death Valley is a functional ecosystem that supports highly specialized organisms and remains exceptionally sensitive to both climatic and anthropogenic disturbances.

Traditional Peoples of Death Valley

Archaeological evidence indicates that humans have occupied the Death Valley region for more than 9,000 years, primarily Indigenous groups such as the Timbisha Shoshone. These peoples developed highly sophisticated strategies for survival in an extreme desert environment.

The Timbisha Shoshone (also known as Tümpisa Shoshone) are an Indigenous people native to the southwestern United States, historically associated with Death Valley and adjacent areas of California and Nevada. They belong to the broader Shoshone (or Shoshonean) cultural and linguistic group, which is part of the Uto-Aztecan language family—one of the most widespread linguistic families in North America [34].

The name *Timbisha* (or *Tümpisa*) derives from a term associated with "rock paint" or "red ochre," a mineral abundant in the region and traditionally used for ceremonial and decorative purposes. For the Timbisha, Death Valley was not a land of death, but a habitable and sacred homeland known as *Tümpisa*.

The traditional territory of the Timbisha Shoshone encompassed what is now Death Valley, parts of the Amargosa Valley, mountainous areas of the Panamint Range, and regions that today lie within California and Nevada. They practiced a seasonal pattern of land use, moving between the valley floor and higher elevations according to the time of year.

To live in such an extreme desert environment, the Timbisha Shoshone developed highly refined subsistence strategies, including the gathering of native plants (seeds, roots, and fruits), hunting of small mammals and birds, the use of pinyon pine nuts from higher elevations as a staple food, and careful management of springs and oases. This way of life reflected deep ecological knowledge and a strong ethic of environmental balance.

Timbisha society was organized around extended family groups, with flexible leadership based on knowledge, experience, and community respect rather than rigid hierarchy. Their culture placed great value on oral tradition, intimate knowledge of the land, and spiritual relationships with the landscape. Mountains, water sources, and geological formations held symbolic and spiritual meaning and were integral to cultural identity.

Contact with European explorers and settlers intensified during the nineteenth century, particularly during the Gold Rush [35, 36] and the expansion of mining activities, including borax and silver extraction. This period brought devastating consequences: widespread violence, loss of ancestral lands, introduced diseases, and forced displacement. Despite these pressures, the Timbisha Shoshone managed to maintain a continuous presence in their homeland.

Today, the Timbisha Shoshone are federally recognized as the Timbisha Shoshone Tribe. In 2000, the U.S. government returned a portion of their ancestral land within Death Valley National Park—an unusual and significant case of Indigenous land restitution within a national park. The contemporary Timbisha community continues to preserve its cultural traditions, participate in park management, and contribute to environmental education and historical preservation.

The Timbisha Shoshone stand as a powerful example of cultural resilience and human adaptation to extreme environments, as well as survival in the face of colonial violence. Their history challenges the notion that Death Valley was ever an uninhabitable wasteland and underscores the importance of Indigenous knowledge in understanding and conserving complex natural landscapes.

Human Resilience in Death Valley and Indigenous Dispossession

The long-term survival of the Timbisha Shoshone in the Death Valley region reflects not only exceptional human adaptability to extreme environmental conditions, but also a specific historical context that partially limited large-scale colonial violence when compared to other regions of California. While many Indigenous groups across the state were subjected to systematic massacres during the nineteenth century, Death Valley's extreme aridity and low agricultural potential reduced sustained colonial settlement, thereby limiting, though not eliminating, direct extermination campaigns.

The westward expansion of the United States was not a neutral or purely exploratory process, but one deeply structured by territorial appropriation, coercion, and violence against Indigenous populations. Under the ideological framework of Manifest Destiny [37], Indigenous lands were systematically seized, natural resources intensively exploited, and traditional societies dismantled through a combination of military force, legal mechanisms, and economic pressure.

Historical and anthropological scholarship demonstrates that, in many regions of California, these processes resulted in organized massacres, forced removals, demographic collapse, and cultural destruction, events increasingly recognized in the academic literature as constituting genocide [38, 39]. Violence was not incidental but structural, supported by state policies, militias, and legal systems that normalized dispossession and impunity.

In contrast to agriculturally productive regions, the extreme aridity and limited water availability of Death Valley reduced sustained colonial settlement. This environmental constraint partially limited the scale of direct extermination campaigns experienced elsewhere in California. However, the relative absence of large-scale massacres should not be interpreted as an absence of colonial violence. Massacres against Indigenous populations were deliberate, organized, and carried out with broad impunity, often during religious ceremonies, with women, children, and the elderly as the primary victims.

Throughout the second half of the nineteenth century, the Timbisha Shoshone and neighboring Indigenous groups were subjected to forced displacement from key water sources, disruption of seasonal mobility patterns, and coerced labor in mining and ranching economies. The expansion of mining activities, particularly related to precious metals and borax extraction, intensified pressure on Indigenous territories and undermined long-established subsistence strategies.

Colonial policies further contributed to social disintegration through the suppression of Indigenous languages, spiritual practices, and ceremonial life. Children were frequently removed from their families and placed in boarding schools designed to erase Indigenous identities. In parallel, the introduction of infectious diseases such as smallpox and measles caused severe demographic decline, reinforcing patterns of dispossession without the necessity of continuous military violence.

Tourism in Death Valley

Today, Death Valley National Park receives millions of visitors each year and represents one of the most emblematic destinations for desert tourism worldwide. Its appeal lies in the combination of extreme landscapes, geological diversity, and accessibility to visually striking features that illustrate long-term natural processes.

Among the most visited areas are Badwater Basin, Zabriskie Point, Dante's View, Artist's Palette, and extensive sand dune fields. These sites offer contrasting perspectives of the valley's geomorphology, ranging from deeply eroded sedimentary formations to expansive salt flats and elevated panoramic viewpoints.

Zabriskie Point stands out for its highly eroded terrain and layered sedimentary structures, which vividly express the valley's geological history. The area is shaped by fine-grained sediments deposited during periods of higher humidity and subsequently sculpted by episodic rainfall and surface runoff. The site provides an accessible and visually compelling setting for interpreting desert erosion processes and landscape evolution (**Photos 13-30**).

Dante's View offers one of the most dramatic panoramas in the park, revealing the vertical contrast between the valley floor and surrounding mountain ranges. From this elevated vantage point, visitors can observe the structural features of the Basin and Range province, including fault-controlled basins and uplifted mountain blocks. The marked temperature difference between the viewpoint and the valley floor also highlights the role of altitude in shaping desert microclimates.

Artist's Palette is renowned for its multicolored slopes, produced by hydrothermal alteration and mineral oxidation within volcanic rocks. The visual intensity of these formations makes the site a focal point for both tourism and geoscientific interpretation, demonstrating the link between mineralogy, weathering, and landscape aesthetics (**Photo 43**).

Tourism management in Death Valley emphasizes regulated access, visitor education, and environmental protection. Infrastructure such as designated trails, observation platforms, and interpretive signage is designed to minimize ecological disturbance while promoting scientific understanding. Given the fragility of desert ecosystems, maintaining a balance between public use and conservation remains a central challenge.

The photos presented in this report were taken by Fabio Rossano Dario and Cristina De Vincenzo, using a cellphone and a Canon PowerShot digital camera.

CONCLUSIONS

Death Valley constitutes one of the most extreme yet scientifically illuminating natural systems on Earth, integrating geological, ecological, historical, and cultural processes within a single landscape. Geologically, it represents a classic expression of Basin and Range dynamics, where crustal extension, volcanism, lacustrine sedimentation, and evaporitic processes have produced exceptional topographic contrasts, including the coexistence of Badwater Basin—the lowest point in North America—and abruptly elevated mountain ranges. These features establish Death Valley as a natural laboratory for understanding tectonic and climatic evolution in arid continental environments.

Historically, Death Valley challenges the persistent perception of deserts as empty or marginal spaces. Indigenous peoples, particularly the Timbisha Shoshone, developed complex and sustainable strategies for inhabiting this landscape over millennia, grounded in detailed ecological knowledge and seasonal mobility. Although the region experienced fewer large-scale massacres than other parts of California, Euro-American expansion nonetheless produced long-term processes of territorial dispossession, cultural suppression, and economic marginalization, primarily linked to extractive activities. Recognizing this history is essential for understanding Death Valley not only as a natural system, but also as a cultural and historical landscape shaped by unequal power relations.

From an ecological perspective, Death Valley reveals the limits and adaptability of life. Highly specialized species of flora and fauna demonstrate extreme physiological and behavioral adaptations, making the region a key setting for research in evolution, ecophysiology, conservation biology, and climate change. Beneath its apparent simplicity, the desert conceals a complex and interconnected ecosystem that is highly sensitive to environmental disturbance.

As a tourist destination, Death Valley combines scenic, scientific, and educational value. Its iconic viewpoints and geological formations offer opportunities not only for visual appreciation but also for scientific dissemination and reflection on human interactions with extreme environments. Effective tourism management is essential to ensure that public access does not compromise ecological integrity.

In summary, Death Valley transcends its reputation as an inhospitable landscape to emerge as a territory of exceptional scientific, historical, and cultural significance. Its continued preservation and study are essential for advancing knowledge of extreme environments and for recognizing the long-standing human presence that has shaped, and been shaped by, desert landscapes over time.

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Appendix

Photo 1. Entering the state of Nevada, heading towards Death Valley.

Photo 2. Nevada Desert, USA.

Photo 3. Quick drive through Las Vegas, Nevada.

Photo 4. Crossing into California, en route to Death Valley.

Photo 5. Near Area 51 in Nevada's desert.

Photo 6. Nevada Desert in the background.

Photo 7. Funeral Mountains – along the California–Nevada border.

Photo 8. Death Valley, California.

Photo 9. Pyramid Peak – highest point of the Amargosa Range, Funeral Mountains, Death Valley National Park.

Photo 10. Death Valley, California.

Photo 11. Entrance to Death Valley National Park, California.

Photo 12. Death Valley National Park.

Photo 13. Death Valley National Park: heading toward Zabriskie Point.

Photo 14. Death Valley National Park: heading toward Zabriskie Point.

Photo 15. Death Valley National Park: heading toward Zabriskie Point.

Photo 16. Twenty Mule Team Canyon.

Photo 17. Zabriskie Point, Death Valley.

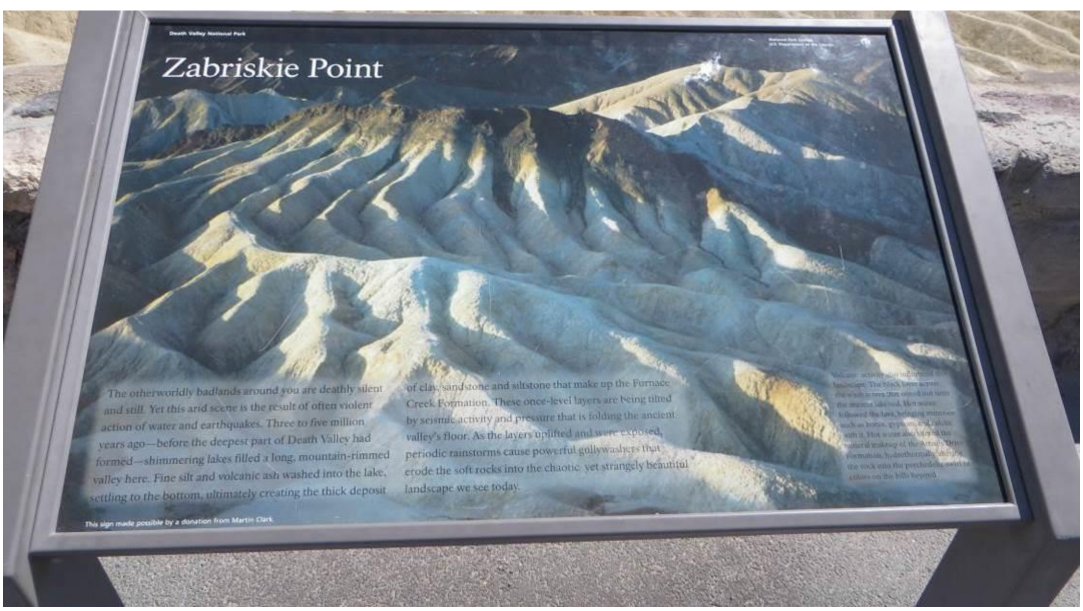

Photo 18. Zabriskie Point.

Photo 19. Zabriskie Point stands out for its highly eroded terrain and layered sedimentary structures, which vividly express the valley's geological history.

Photo 20. Zabriskie Point provides an accessible and visually compelling setting for interpreting desert erosion processes and landscape evolution.

Photo 21. Chasing views at Zabriskie Point.

Photo 22. Zabriskie Point, Death Valley.

Photo 23. View of Zabriskie Point, California, showing convolutions, texture, and color contrasts in the eroded rock.

Photo 24. Zabriskie Point, Death Valley.

Photo 25. Zabriskie Point, Death Valley.

Photo 26. Epic views: Zabriskie Point.

Photo 27. Zabriskie Point, Death Valley.

Photo 28. Zabriskie Point, Death Valley.

Photo 29. Zabriskie Point is a part of the Amargosa Range located east of Death Valley in California.

Photo 30. Zabriskie Point, Death Valley.

Photo 31. Death Valley National Park, California.

Photo 32. Death Valley National Park, California.

Photo 33. Death Valley National Park, California.

Photo 34. Death Valley National Park, California.

Photo 35. Death Valley National Park, California.

Photo 36. Death Valley National Park, California.

Photo 37. Badwater Rd, Death Valley National Park.

Photo 38. Death Valley National Park, California.

Photo 39. Badwater Rd, Death Valley National Park.

Photo 40. Badwater Rd, Death Valley National Park.

Photo 41. Death Valley National Park, California.

Photo 42. Death Valley National Park, California.

Photo 43. Artist's Palette is renowned for its multicolored slopes.

Photo 44. Death Valley National Park, California.

Photo 45. Death Valley National Park, California.

Photo 46. Death Valley National Park, California.

Photo 47. Death Valley National Park, California.

Photo 48. Salsola tragus is a plant introduced from Russia that often appears in films set in the deserts of the United States, forming dry rolls carried by the wind; it is known as tumbleweed.

Photo 49. Death Valley National Park, California.

Photo 50. Death Valley National Park, California.

Photo 51. Death Valley National Park, California.

Photo 52. Death Valley National Park, California.

Photo 53. Badwater Basin is one of the most emblematic locations within Death Valley National Park and represents the lowest topographic point in North America, situated approximately 86 meters below mean sea level.

Photo 54. The landscape of Badwater Basin is dominated by extensive salt flats that cover tens of square kilometers.

Photo 55. Badwater Basin, Death Valley National Park.

Photo 56. Badwater Basin, Death Valley National Park.

Photo 57. A boundless plain coated in salt.

Photo 58. Salt crystals.

Photo 59. In this below-sea-level basin, steady drought, and record summer heat make Death Valley, in California, a land of extremes, reaching 54 ºC, considered the highest temperature on Earth.

Photo 60. The Devil's Golf Course in Death Valley National Park is a surreal expanse of jagged, salt-encrusted earth, named because its razor-sharp spires are so rough "only the devil could play golf" on them.

Photo 61. Frequent winds contribute to erosion and sediment transport, leading to the formation of extensive dune systems, such as the Mesquite Flat Sand Dunes.

Photo 62. Death Valley National Park, California.

Photo 63. Death Valley National Park, California.

Photo 64. Death Valley National Park, California.

Photo 65. Death Valley National Park, California.

Photo 66. Panoramic view from Death Valley, in California.

Photo 67. Death Valley is a down dropped block of land between two mountain ranges. It lies at the southern end of a geological trough called Walker Lane, which runs north to Oregon.

Photo 68. Death Valley National Park, California.

Photo 69. Death Valley National Park, California.

Photo 70. Death Valley National Park, California.

Photo 71. Joshua Tree (*Yucca brevifolia*), a desert plant named by Mormon pioneers because its branches resemble the biblical prophet Joshua with his arms raised in prayer.

Photo 72. A gnarled clump of Yucca brevifolia, rising from the desert floor in tangled, branching forms.

Photo 73. Leaving Death Valley, heading toward the Sierra Nevada.

Photo 74. Leaving Death Valley, heading toward the Sierra Nevada.

Photo 75. View of the Sierra Nevada, California.

Photo 76. View of the Sierra Nevada, California.