World Heritage Sites

Protected Areas and World Heritage

SWISS TECTONIC ARENA SARDONA SWITZERLAND

This striking overthrust formation in the eastern Alps is a dramatic mountain landscape where peaks of ancient dark-coloured rock are clearly seen to overlie lighter rocks some 150-250 million years younger. The formation spectacularly exposes proof of overthrust mountain building, and is historically important as the classical locus of nappe theory and thrust tectonics which underlay Wegener's theories of continental drift and plate tectonics. Because of the clarity of its geological relationships, it continues to be important for scientific research and education.

COUNTRY
Switzerland

NAME
Swiss Tectonic Arena Sardona

NATURAL WORLD HERITAGE SITE
2008: Inscribed on the World Heritage List under Natural criterion viii.

STATEMENT OF OUTSTANDING UNIVERSAL VALUE
The UNESCO World Heritage Committee issued the following Statement of Outstanding Universal Value at the time of inscription:

Values
The Swiss Tectonic Arena Sardona presents an exceptional and dramatic display of mountain building through continental collision. The property is distinguished by the clear three-dimensional exposure of the structures and processes that characterise this phenomenon in a mountain setting, its history of study, and its ongoing contribution to geological sciences.

Criterion (viii): Earth's history, geological and geomorphic features and processes: The Swiss Tectonic Arena Sardona provides an exceptional display of mountain building tectonics and has been recognised as a key site for geological sciences since the 18th century. The clear exposure of the Glarus Overthrust is a key, but not the only significant, feature. The exposures of the rocks below and above this feature are visible in three dimensions and, taken together, have made substantial contributions to the understanding of mountain building tectonics. Its geological features can be readily appreciated by all visitors. The property can be differentiated from other similar sites by the combination of the clear exposure of the phenomenon in a mountain setting, its history of study, and its ongoing contribution to geological sciences.

Integrity
The property contains the full range of tectonic features necessary to display the phenomenon of mountain building. Key attributes of the site include the Glarus Overthrust and the associated folded and faulted geological exposures above and below it. Other key attributes of the property are the accessibility of the features in three dimensions, and access to the thrust surface of the Glarus Overthrust. Associated intangible values relate to the importance of the property as a formative site for the geological sciences; and the features that were part of these studies remain visible and in good condition in the present day.

Protection and Management Requirements
The major exposures of the geological features are within protected areas and are substantially unthreatened. The primary management issue is to allow the natural processes of slope erosion to continue. Other key management issues relate to the continued provision of safe visitor and research access and protection of key features such as the exposures of the thrust surface. The communication of the key values of the property is also an important priority and continued investment and enhancement of visitor interpretation and education strategies are required.

IUCN MANAGEMENT CATEGORY
Unassigned

BIOGEOGRAPHICAL PROVINCE
Central European Highlands (2.34.12).

GEOGRAPHICAL LOCATION
This overthrust formation is in the Glarner Alps of eastern Switzerland, south of the Walensee lake and north and west of the Upper Rhine valley (Vorderrheintal). The site is centred on the peak of Piz Sardona where the cantons of St. Gallen, Glarus and Graubünden meet at 46°55'N by 9°15'E.

DATES AND HISTORY OF ESTABLISHMENT
1966: The Federal Law on the Protection of Nature and Cultural Heritage (LPN, RS451) and the Ordinance concerning the Federal Inventory of Landscapes and Natural Monuments passed. These cover the protection of sites of national importance;

1999: The Sarganserland-Walensee-Glarnerland GeoPark established, covering nearly all the site;

2003: St.Gallen canton master plan approved by the Federal Council. It protects all designated reserves, protected landscape areas and habitats within the nominated area and canton;

2004: Glarus canton: A new master plan proposed, incorporating an inventory of sites designated in 1996 under the cantonal Nature and Cultural Heritage Protection Ordinance. It will protect all designated habitat areas, protected landscape areas and wildlife refuges within the nominated area and canton;

2003: Graubünden canton master plan approved by the Federal Council. It protects a national mire landscape, all nature reserves and protected landscape areas within the canton;

2005 &2006: Nomination for World Heritage status rejected as a site of regional not global significance.

LAND TENURE
St.Gallen canton includes 47.46% of the site and the land is owned by alpine corporations; Glarus canton covers 38.7% of the site with nine communes owning 80% of the land, corporations 10% and private owners 10%; Graubünden canton covers 13.84% of the site, the land being held by citizens' associations. Management is exercised jointly, depending on the administration, federal, cantonal, communal or other authority responsible for protection. No single agency therefore bears sole responsibility.

AREA
32,850 ha.

ALTITUDE
~ 570m (Lochsite near Sool) to 3,257m (Ringelspitz/Piz Barghis).

PHYSICAL FEATURES
The Glarus Alps in eastern Switzerland between the valley of the upper Rhine, the Walensee and River Linth form an impressive glaciated landscape rising steeply above narrow farmed valleys. They are little vegetated above 2,000m where the highest peaks carry the relics of Ice Age glaciation and sixteen small diminishing glaciers. There are seven peaks higher than 3,000m, 20 small lakes including the Gigerwald upper reservoir, and many streams, mires, raised bogs, fens, alluvial zones and dry grasslands. The soils are acidic or alkaline, depending on the underlying rock, and where clayey become waterlogged mires. The abundance of water creates a continuing hazard of landslides and rockfalls, two of which in the recent past have been disastrous.

The Swiss Tectonic Arena Sardona formation known as the Glarus overthrust has one of the world's largest and most dramatically visible sections through a tectonic thrust-fault plane in the Earth's upper crust. A system of stacked nappes and deep ancient rocks is visible at intervals over a distance of 50 km, laid bare by glacial erosion. This is the result of the slow overlapping of a knife-edge thrust - not fold - of dark-coloured old rocks over younger light-coloured rocks along a lubricant layer of limestone. It arches northwards from 600m in the upper Rhine valley in the south to over 3,000m in the Ringelspitz massif then falls more steeply northwest to Lochsite near Sool in the west where it is best observed. There it dips underground and under the Walensee to rise and reappear north of it. The whole

displacement by some 35 kilometers of a domed block 3 km thick, 50 km long and over 100 km wide occurred at great heat and pressure deep under the Earth's surface some 30 to 20 million years ago and subsequently brought to the surface by tectonic mountain building. The thrust fault is accompanied by folds, thrust sheets and deformed rock layers exposed in spectacular three dimensional sections by glacial action.

This overthrust structure is now the key scenic element of over 30 km of landscape from Lochsite in the west to Pizol in the east, and over 20km from Flims in the south to the Weisstannenthal in the northeast. It is clearly visible and the sequence is deeply sectioned by glacial valleys. Mountain peaks of dark grey-green or purple-red slates, sandstones and conglomerates of the Permian (250–300 million year old) Verrucano group forming the Helvetic nappes overlie light grey-beige limestone 100–150 million years old and brownish grey, generally schistose, flysch formations 35–50 million years old. Pebbles in the darker Verrucano conglomerate are laterally deformed proving formation under great subterranean pressures. Beneath the lowest flysch is a crystalline basement with a cover of Permian sedimentary rocks, also showing small nappe formations. Fine exposures of the overthrust are seen from deeply cut valleys in the Ringelspitz mountains, the Pizol region, the Foostock, Weisstannental, Lochsite, Tschingelhoren, the Sardona mountains and the Fil de Cassons-Crap da Flem range. The best known exposures are at Martin's Loch and Lochsite.

CLIMATE

The annual mean temperature in the surrounding valleys is 7.7°C. In January it is -1.3°C, in July, 16.3°C. The average rainfall is 1,317mm at 1,000m but 2,000-2,300mm at 2,000m, and 2,800mm in the high mountains. The surrounding Rhine, Seez and Linth valleys experience dry southerly föhn winds.

VEGETATION

Owing to the variety of geological substrates, elevations and topographical features, the plant communities are very diverse for a northern Alpine region. However, much of the proposed site lies above the tree line, the important vegetation is therefore primarily subalpine and alpine. There are about 800 vascular plant species, including just under 50 species protected at the national level, including a number of Tertiary relicts, such as the buttercup *Callianthemum coriandrifolium*, crowfoot *Ranunculus parnassifolius* and the Primulaceae *Androsace pubescens*.

Up to about 1,100m there are pure beech *Fagus sylvatica* forests which give way to beech–silver fir *Abies alba* forests to 1,300-1,400m. On damp shady slopes are forests of sycamore *Acer pseudoplatanus* with wych elm *Ulmus glabra*. Above these, silver fir and Norway spruce *Picea abies* forests predominate, the shrub layer species determined by the pH of the soil. Above these spruce is dominant with some Swiss mountain pine *Pinus mugo* ssp*.uncinata* with alpenrose *Rhododendron* species. Dwarf mountain pine *Pinus mugo* ssp.*mugo* colonizes avalanche paths in dry areas. The natural treeline is at 1,700-2,000m but has been lowered 100–200m by forest clearance for grazing. Some native trees remain however: arolla pine *Pinus cembra* grows up to 2,100m, the northernmost examples of relatively extensive stands in Europe. And around 2,000-2,100m, thickets of green alder *Alnus viridis* colonise meadows of rusty sedge *Carex ferruginea,* among other characteristic and rare subalpine species.

At and above the treeline are a few hay meadows but most of the grassland is used for mountain farming. On drier soils between 1,600 and 2,200m, mat-grass *Nardus stricta* pastures predominate, showing marked floristic variation, depending on elevation and grazing intensity, becoming dwarf shrub heath when ungrazed. Dry steep slopes on base-rich rock are generally covered by blue moorgrass-evergreen sedge swards which are often intensively grazed. These swards, dominated by blue moorgrass *Sesleria caerulea* and evergreen sedge *Carex sempervirens* are generally very species-rich, with numerous alpine flowers; there are also some rare and protected species such as edelweiss *Leontopodium alpinum*. On the higher plains there are various types of mire: fens are the most widespread, occurring in small patches at subalpine and alpine elevations throughout, with a wide range of algal species. Raised bogs, some of national importance, have rare species such as mud sedge *Carex limosa* and round-leaved sundew *Drosera rotundifolia*. Seepage communities include ice sedge *Carex frigida* and yellow mountain saxifrage *Saxifraga aizoides*. In alluvial riparian zones, rare plant communities develop beside glacier-fed streams on sandy soils and moraine substrates. Plaun Segnas Sut at 2100m is one of Switzerland's largest mire landscapes and most beautiful alpine alluvial plains, which harbours species such as bicoloured sedge *Carex bicolor* and three-flowered rush *Juncus triglumis*. Plaun Segnas Sura is an extensive mire-free plain with a large glacier foreland of

national importance. Large parts of the nominated site are covered by alpine rock and scree communities, where the nature of the flora depends on the pH of the substrate rocks.

FAUNA

The region's animals are typical of northern Alpine Switzerland, with few large mammals, but due to the lack of tourist infrastructure they are relatively undisturbed. Above the treeline are mountain hare *Lepus timidus* and alpine marmot *Marmota marmota,* alpine ibex *Capra ibex* (reintroduced in 1911) and northern chamois *Rupicapra rupicapra;* lower down, mainly in the forests, are red and roe deer *Cervus elaphus* and *Capreolus capreolus* and pine marten *Martes martes,* red fox *Vulpes vulpes*, badger *Meles meles*, Eurasian lynx *Lynx lynx* and red deer. 85 species of birds breed on the nominated site, rarer species among them being hazel grouse *Bonasia bonasia*, capercaillie *Tetrao urogallus*, boreal owl *Aegolius funereus*, pygmy owl *Glaucidium passerinum* and northern three-toed woodpecker *Picoides tridactylus*. Birds of the high mountains include golden eagle *Aquila chrysaetos,* lammergeier *Gypaetus barbatus,* Alpine chough *Pyrrhocorax graculus*, and snow finch *Montefringilla nivalis.* There are 5 fish, 2 amphibian, 6 reptile species and, owing to the diversity of habitats, uncounted numbers of invertebrates including 90 species of butterfly.

CONSERVATION VALUE

The Swiss Tectonic Arena Sardona formation is an extremely dramatic landscape where dark mountain peaks of ancient rock are clearly seen to overlie lighter rocks some 150-250 million years younger. The formation spectacularly exposes proof of overthrust mountain building, and is historically important as the classical locus of nappe theory and thrust tectonics, which underlay the later theories of continental drift and plate tectonics. It continues important for scientific research and education because of the clarity of its geological relationships. The Park lies within a WWF/IUCN Centre of Plant Diversity.

CULTURAL HERITAGE

Until the 17th century the area was settled by the Walser people who used to clear-fell south-facing valley slopes for pasture. But from the mid-15th century onwards, the Walsers abandoned the area because of the deteriorating climate and the more frequent avalanches triggered by forest clearance. In more recent times, the area around the site was known for the mining of iron, silver, copper, gypsum and slate quarrying. Most of the population is German-speaking, but the native language of some of the population in the canton of Graubünden is Romansh.

LOCAL HUMAN POPULATION

Today the nominated area is uninhabited except for seasonal workers in the mountain tourist cabins, sports facilities and pastures. But there is still mountain farming with many mountain summer shelters, with some agriculture, forestry, hunting, fishing, and some use for power generation and by the army for firing ranges. There are 68 mountain farms within the proposed boundary with, in 2002, around 2,700 cattle, 5,300 young stock, just under 7,000 sheep, 450 goats, and 50 horses and donkeys. Pastures up to 2500m are grazed in the traditional manner from June to September only by dairy and beef cattle and sheep. However, grazing is declining, and is being succeeded by new forms of management. Steep and less favoured areas are also no longer grazed, allowing scrub to develop. There are a few high hay meadows but little of the nominated area lies in the lower year-round farmland below 1,000m. The forests, after extensive clearing, logging and destructive storms in the 19th century, were legally protected and replanted with Norway spruce. Hunting is sustainable, well accepted and well regulated on a cantonal basis, most of the larger mammals being regularly culled.

VISITORS AND VISITOR FACILITIES

Tourism is of major economic significance for all the cantons. In the Flims area in the south almost the entire population is directly or indirectly dependent on tourism, and in the other surrounding communes the same applies to a large proportion of the population. The development of winter sports resorts began with the first ski lifts in the middle of the 20th century. In winter, the average number of visitors per day is now 8,000 in the southern resorts of Flims-Laax-Falera, 5,000 (13,000) on Flumserberg, and 1,500 (3,500) in the Pizol region. Transport facilities and infrastructure are nearly all outside the nominated area. Within it are 8 mountain cabin-hotels and several mountain huts offering bed and board. A program of dissemination of knowledge about the site for visitors and local people who, with scientists, will be trained as geo-guides. Conditions make the alpine and high-alpine zones unsuitable

for mass tourism, but in the surrounding valleys there are excellent roads and railways and Zurich airport is 1-2 hours away by road.

Exhibitions and collections exist at the Museum of Nature in Chur, Graubunden, the Nature Museum at Engi in Glarus canton, and the Sarganserland Museum, Sargans, St. Gallen canton. The Sarganserland-Walensee-Glarnerland GeoPark, launched in 1999 exploits the potential for instruction in geology and mining of the region. The emphasis is on tourism, education and research but also on quarrying and mineral processing. The geo-programme offers more than 40 attractions: guided tours of geotopes, disused mines, quarries and the Hagerbach Test Gallery, as well as geo-trails, geo-cruises, museums and exhibitions. It has produced educational charts, booklets, website, conferences and publications in the earth sciences, and will set up subsidiary centres in all three cantons.

SCIENTIFIC RESEARCH AND FACILITIES

For nearly 200 years the area has attracted intensive study, as one of the most celebrated sites for the history of geological ideas, resulting in a great number of publications. Explanation of the nappes long challenged geologists: H. Escher in 1807 noted the Glarus unconformity did not confirm current geological theory. His son A. Escher mentioned the concept of overthrust. It remained a source of other more complex theories until the overthrust theory was confirmed in 1884 from another site (Moyenne Durance) by M. Bertrand and officially accepted by 1903. The most visible site, the Lochsite limestone, became famous and there followed three most productive decades of Alpine geological studies. The overthrust observation led to the theory of continental drift by Wegener in 1912 which was confirmed by the theory of plate tectonics, which gained acceptance in the 1960s.

The area continues to be the site of many studies especially in sedimentology, tectonics and Quaternary geology, also in biology and tourism. The flora and fauna are regularly sampled and the data published. Management of scientific knowledge about the area is the responsibility of the Secretariat and the Scientific Advisory Committee of the communal Delegates Assembly Committee which will promote and coordinate scientific and socio-economic research at several universities. A centralised repository of scientific literature and information is being set up with a website and a program of dissemination of knowledge about the site. The geology library of the Swiss Federal Institute of Technology in Zurich and a collection of the works of Jakob Oberholzer, one of the most important past researchers in the field, will become accessible to the public in Engi in 2004. In time the nominated property may come to lie entirely within an international GeoPark and the obvious synergies could be more fully developed.

MANAGEMENT

The Swiss Tectonic Arena Sardona formation was nominated as the Glarus Overthrust for inclusion in UNESCO's World Heritage List by the local communes, together with the cantons of St. Gallen, Glarus and Graubünden. Each canton adopted a masterplan between 2002 and 2004, approved by the Federal Council and binding on all authorities. As jurisdiction over the area was divided between so many authorities they combined in 2003 in a Delegates Assembly Committee with a Regional Management Secretariat, Scientific Advisory Committee and Working Groups. This Committee prepared and approved an *Agreement on Joint Action to Protect the UNESCO World Natural Heritage Site 'Glarus Overthrust',* including a Development Plan and a table listing acceptable and unacceptable uses. The Agreement was implemented through an assembly of delegates and a Secretariat. It defined the purpose and nature of cooperation between the parties, covered organizational, financial and legal aspects and formed the essential basis of the present Regional Management Plan. This aims to conserve the overthrust with the surrounding landscapes, habitats and wildlife but also to welcome and inform visitors.

The area is a geotope of national importance. It is both undeveloped and uninhabited and the many small protected areas within the area have good natural as well as legal protection. This covers the national nature reserves, mires, alluvial zones, raised bogs, fen lands, amphibian spawning areas, dry grasslands, game reserves, ibex colonies and a range of geotopes, totalling some 30 sites. Also covered are some 80 cantonally protected landscape and habitat areas, wildlife refuges, wetlands, aquatic and alluvial zones. There is a national Forest Development Plan which is binding on the authorities. Mining, new military or tourist roads, buildings and infrastructure, major pipes and powerlines, dumping, camping, littering, heli-skiing and airstrips are not permitted. Annual monitoring will be done of the biological, environmental, climatic and glacial, and socio-economic indicators such as visitor numbers, overnight stays, constructions and the state of paths.

MANAGEMENT CONSTRAINTS

Most of the site is well preserved by its inaccessibility except at the Lochsite exposure and does not require a buffer zone, though it is necessary to control hammering of the exposures. Traditional forestry, mountain farming and hunting are well regulated and there is no mining. Between 1850 and 1973 global warming has caused the sixteen local glaciers to retreat in length by 54%, in area by 53% and in volume by 59%. Trampling of hillsides by cattle, susceptibility to heavy rains and the subsequent water-logging has created unstable slopes, resulting in erosion, rockfalls, landslides and debris flows, which can threaten valley communities just outside the site. There are adjacent heavily used winter tourism areas, but these do not spread onto the site.

COMPARISON WITH SIMILAR SITES

The Swiss Tectonic Arena Sardona formation is an outstanding example of historical geologic processes and geomorphological features displayed in superb scenery. Its uniqueness lies in the clarity of its geological structure and geomorphic expressiveness, its scientific history and its educational value. It is one of the world's largest, longest and most explicit examples of the overthrusting of a layer of ancient rock over rocks some 150-250 million years younger; and of mountain building by the convergence of tectonic plates. It was first recognised as a thrust in 1884 and partly from this evidence Wegener adduced the theory of continental drift, precursor to the theory of plate tectonics. It occurs in mountains of great visual quality, with a rich undisturbed alpine flora and a typical alpine fauna and landscape. However, there are many structures of similar character, many in landscapes of similarly high quality. A detailed comparison was made for the resubmission, refereed by eminent scientists (Pfiffner & Schmid, 2008). The main criteria applied in the comparison were: the existence of overthrusting as opposed to simple folding; visibility and accessibility on the ground to laymen as well as scientists; its length, size, age and difference in age and colour between layers; the eloquence of its geomorphology and the amount that it has been studied with its consequent significance and value to education. Other examples are found throughout the world, but not all these can be comprehensively compared, because the displacement is often concealed from view.

The Caledonides such as the Moine thrust belt in north-western Scotland and the Jotun thrust in Norway have larger more complex structures which are therefore somewhat less discernable. The Rocky Mountains in Alberta, Montana and near Las Vegas have some well exposed structures but they are not easily perceived on the ground. Notably visible and scenic exceptions are the McConnell thrust on Mt Yamnuska, Alberta and the Lewis thrust in the Waterton/Glacier International Peace Park. The color-contrasted rocks in the Cirque de Gavarnie in the Pyrénées-Mont Perdu World Heritage site are similar but smaller in scale, less studied and so scientifically less influential. In the Moyenne Durance fault near Gap in Provence, an overthrust is visible but smaller. The Helvetic nappes, especially in the Zermatt area, are impressive but the thrust surfaces are less instructive. There are overthrusts in several other Alpine sites but nearly all are poorly exposed: the Préalpes Médianes in France, the Säntis and Ratikon Mountains, the Engadine and Upper Lech in Switzerland, and in Austria, the Hohe Tauern and Salzkammergut. But tourists are better served at these places than at most other thrust sites. Large thrusts in the Peruvian Eastern Cordillera, the Himalayas and Te Wahiponauru in southern New Zealand often cannot be directly observed; some are covered in forest and most have been little studied because of their remoteness and great size: the Main Central Thrust in Nepal is among the best known but is not very accessible. Thrusts in the Rif and Namibia cannot be directly observed.

In sum, the Swiss Tectonic Arena Sardona formation is not only a clearly visible, large but compact example of overthrust, but influential in scientific theory, easily interpretable, fine scenery and, although the area is preserved from development by its steepness, it is very accessible from the valleys below.

STAFF

There are no staff exclusively responsible for the property at present. The cantonal or federal agency officials responsible for nature and landscape protection are graduate scientists and engineers. The Scientific Advisory Committee will advise and support them. Rangers are drawn from existing organizations and given supplementary instruction. They guide and manage visitors and will add monitoring and evaluation duties. From 2004, geo-guides in the GeoPark will join them. Paths and roads will be maintained by tourist operators, road owners, and the communal and cantonal authorities.

BUDGET

An annual budget of CHF100,000 (US$84,000) would be borne by the federal (50%), cantonal (25%) and communal authorities (25%), a commune's expenditure being proportionate to its number of voters. About 60% will pay for the regional management (Secretariat), to cover the costs of personnel

and infrastructure. Another 20% is to be allocated to payments for the various bodies and the remaining 20 % to unforeseen items.

LOCAL ADDRESSES

The Head, Protected Areas, Swiss Agency for the Environment, Forests & Landscape, CH-3003 Bern.

The Director, Amt für Raumentwicklung, Lämmlisbrunnenstrasse 54, CH-9001 St.Gallen.

The Director, Amt für Umweltschutz, Postgasse 29, CH-8750 Glarus.

The Director, Amt für Natur und Umwelt, Gürtelstrasse 89, CH-7000 Chur, Graubünden.

IG UNESCO-Weltnaturerbe, Glarner Hauptüberschiebung, Untergasse 19, CH-8888 Heiligkreuz/Mels.

Website: www.geopark.ch (in German).

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DATE

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