ABSTRACT – The concept of geomorphosites is relatively recent (PANIZZA, 2001), finding application in many European nations, but in Africa much research on geomorphological heritage has still to be done. The research group has started studying landscape units, geomorphology, geomorphosites and geological heritage in different North-African regions, with the aim of drawing thematic geomorphological maps. The choice of these arguments as main objectives of this research is determined by the absolute lack of specific researches on these topics in Morocco. Furthermore, the very interesting landscapes, very rich in geological and geomorphological sites, deserve to be better known, safeguarded and valorised. This research has allowed to realise the first example of Landscape and Geomorphosites Map in Morocco, compiled for the area of Ifrane and Azrou in the Middle Atlas (Central Morocco). This region is already inserted in the classical tourist routes that connect Fes and Meknès with the South of Morocco and this fact, together with its geological and geomorphological variety, has suggested its selection for this type of applied research. The research carried out by means of the analysis of airborne- and satellite images and direct field observations have brought to the recognition of 14 landscape units in which 42 geomorphosites have been selected. These geomorphosites comprise springs, karst landforms (polje, dolines, caves, sinkholes, stone forests, cryptokarstic dolines), carbonate depositional landforms (travertines and waterfalls), fluvial landforms (meanders, canyons, palaeo-valleys, etc.), structural landforms (triangular facets, hogbacks, cuestas, residual outcrops, etc.), volcanic landforms (volcanoes, calderas, pyroclastic cones, lava tube) and two geo-botanical sites. The results of this research have been summarised in a geomorphological map, representing the various landscape units and the geomorphosites, and comprises a proposal for the valorisation of the geomorphological heritage by means of six itineraries. The Map, constructed upon a Landsat ETM+ image, is completed with some geological sketch maps and sections and several photographs of the geomorphosites with their scientific explanation.

KEY WORDS: Geomorphosites, Karst, Geotourism, Mapping, Middle Atlas, Morocco.

RIASSUNTO – Il concetto di geomorfosito è relativamente recente (PANIZZA, 2001) ed ha trovato applicazione in molti paesi europei, ma quasi tutto resta da fare sulla ricerca sui geomorfositi nel continente africano. Il Gruppo di Ricerca ha iniziato a studiare le unità di paesaggio, la geomorfologia, i geomorfositi e il patrimonio geologico in alcune regioni del Nord Africa, con lo scopo di redigere delle Carte Geomorfologiche tematiche. La scelta di questi argomenti come principali obiettivi delle ricerche fu determinata dalla quasi completa assenza di tali studi in Marocco. Inoltre, i paesaggi molto interessanti, in cui abbondano siti di interesse geologico sia geomorfologico, meritano di essere meglio conosciuti, salvaguardati e valorizzati. Questa ricerca ha consentito di realizzare il primo esempio di Carta dei Paesaggi e dei Geomorfositi per il Marocco, comprendendo l’area di Ifrane ed Azrou nel Medio Atlante (Marocco centrale). Questa regione si trova attualmente già inserita in uno dei classici itinerari che collegano le città imperiali di Fès e Meknès con il Sud del Marocco. È proprio questa sua caratteristica, insieme all’abbondanza di siti di interesse geologico e geomorfologico, ad averne determinato la selezione per questo tipo di ricerca applicata. La ricerca, svolta attraverso l’uso di immagini aeree e satellitari ed alcune campagne geologiche sul terreno, ha portato all’individuazione di 14 unità di paesaggio in cui 42 geomorfositi sono stati descritti e catalogati. Questi siti comprendono sorgenti, morfologie carsiche (polje, doline, inghiottiti, paesaggi ruiniformi, doline criptocarsiche), morfologie carbonatiche di deposizione (travertini e cascate), forme fluviali (meandri, gole, paleovalli, ecc.), forme strutturali (facette triangolari, hogbacks, cuestas, forme residuali, ecc.), forme vulcaniche (coni vulcanici, caldeira, coni piroclastici, grotte di lava) e due località di interesse geobotanico.
I risultati di questa ricerca sono stati riassunti in una Carta geomorfologica che rappresenta le varie unità di paesaggio ed i geomorfositi, e comprende una proposta di valorizzazione di questo patrimonio geomorfologico attraverso sei itinerari tematici. La Carta ha come base un’immagine Landsat ETM+, ed è completata da alcuni schemi geologici e diverse fotografie dei geomorfositi con loro spiegazione scientifica.

Parole chiave: Geomorfositi, Carsismo, Geoturismo, Cartografia, Medio Atlante, Marocco.

1. – INTRODUCTION

Geoconservation and Geological Heritage are well-known in Europe since the first debates held in the late 80’s and especially since the birth in 1993 of ProGEO (European Association for the Conservation of the Geological Heritage) from the previously instituted European Working Group for Earth Science Conservation. The European Project GEOSITES, promoted by the International Union of Geological Sciences (IUGS) has induced many European countries and regions to evaluate their geological heritage (AA.VV., 1998; WIMBLEDON et alii, 1995).

Also the term Geomorphological heritage or Geomorphological asset, even though much less common in scientific literature, has also been used since about ten years (BARCA & Di GREGORIO, 1999; CARTON et alii, 1994; PANIZZA & PIACENTE, 1993), while the term “Geomorphosite” has been coined only recently as “a landform with attributes which qualify it as a component of the cultural heritage” (PANIZZA, 2001; PANIZZA & PIACENTE, 2003). In practice, however, many previously described Geosites can often also be defined as Geological Monuments or Geomorphosites.

The whole of this cultural geological revolution has lead to the introduction of the term “Geodiversity” defined as “the range (or diversity) of geological (bedrock), geomorphological (landform) and soil features, assemblages, systems and processes” (GRAY, 2003; SHARPLES, 1995).

Geoconservation, Geological Heritage, Geosites, Geomorphosites and Geodiversity, however, are terms that are not yet properly developed in the African continent, although the first attempts are starting to obtain some preliminary results especially in South Africa (REIMOLD, 1999) and much more recently in some North African countries (DE WAELE et alii, 2005a; DE WAELE et alii, 2005b; OUANAIMI et alii, 2005).

One of the most interesting North-African countries from this point of view is Morocco, a country with a very rich geology, studied by several generations of earth scientists and recognised as one of the most interesting geological regions of the Mediterranean area by most of the modern geological scientific communities. The extraordinary geological succession, characterised by rocks of all sorts of types (igneous, sedimentary and metamorphic) dating from Precambrian up to Holocene, spread over a latitude range of 22-36° North and altitudes from sea level up to 4165 m a.s.l. at Mount Toubkal, have lead to a very rich geomorphological and geological landscape and a very high degree in geodiversity.

For this reason our research team has decided to start a scientific campaign on the Geomorphosites and the Geodiversity of Morocco choosing as a first test site the Middle Atlas of Ifrane-Azrou (EL WARTITI et alii, 2008; DE WAELE & MELIS, 2009) (fig. 1). This research has been carried out by the Laboratories of Environmental Geology and of Remote Sensing (TeleGis) of the Department of Earth Sciences (Cagliari University - Italy) in collaboration with the Laboratory of Applied Geology of the Science Faculty of the University Mohammed V-Agdal of Rabat (Morocco). This Project has benefited of the financial aid of the Sardinian Government (Regional Law 19/1996, cooperation with developing countries).

2. – GEOGRAPHICAL AND GEOLOGICAL SETTING

The Middle Atlas is a SW-NE elongated mountainous chain located between the Atlantic Morocco to the West and the Moulouya plains to the East and forming a physical barrier that separates the Atlantic regions from the eastern parts of Morocco. Towards the South it is bordered by the high mountain ranges of the High Atlas, while to the
North it passes to the Saïss plain and the Rif mountains. From a morphological point of view the Middle Atlas can be subdivided in two main sectors: the northern and western parts are called the Middle Atlas Causses, while in the South and Southwest the “Atlas Moyen Plissé” (or Folded Middle Atlas) is located.

The Middle Atlas Causses are characterised by a series of high plains at altitudes ranging from 1800 m a.s.l. North of Oum Er Rbia to little over 1000 close to El Hajeb, more or less cut by valleys. In the Folded Middle Atlas the landscape is controlled by more or less broad synclines bordered by narrow ridges that can reach altitudes of more than 2000 meters, with a maximum of 2794 at Jbel Tichoukt. The study area is almost entirely located in the Middle Atlas Causses and comprises the villages of Ifrane, El Hajeb, Ain Leuh, Timahdite and Azrou.

This area is located not far South of the imperial cities of Fès and Meknès and covers a surface of more than 3500 square km. It is crossed by the national roads P21 connecting Meknès to Midelt and Ar-Rachidia and the P24 that links Fès to Beni Mellal and Marrakech and is thus one of the crossroads used by foreign visitors to go from North to South Morocco. Furthermore, the area is already well-known for its Cedar forests and ski stations close to the tourist resort of Ifrane.

Climate is of Mediterranean type and is characterised by rainy winters and springs and a long period of drought with intense precipitation during late summer storms. Mean annual rainfall exceeds 900 mm (from 655 mm at El Hajeb – 1050 m a.s.l., over 827 mm at Azrou – 1250 m a.s.l. up to 1122 mm at Ifrane at 1635 m a.s.l.) and mean annual temperature is about 12 °C with very great differences between winter and summer (Ifrane: -4 - 30 °C, El Hajeb: 3-32 °C). Snow is present above 1500 meters of altitude during winter giving sometimes possibility of skiing (stations of Mischliffen and Jbel Hebri).

From a geological viewpoint the outcropping rocks are of metamorphic, sedimentary and volcanic origin and cover a lapse of time ranging from Silurian to Holocene (MARTIN, 1981; MICHAUD, 1976; PIQUE, 1994) (fig. 2). The oldest rocks of the area crop out in a vast territory West of the national road P21 between El Hajeb and Azrou in an erosion window. This interesting and scenographic

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**Croquis géologique**


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**Fig. 2 – Geological sketch map of the study area (modified from MARTIN J., 1981).**

The sedimentary sequence of the study area ends with the lacustrine limestones, sands and conglomerates of Plio-Quaternary age that have infilled the Saïss plain and travertines that locally crop out along the border of the Causses (e.g. El Hajeb).

During Pleistocene also an important alkaline volcanic phase has taken place leaving over 400 square km of basalts with beautiful cones and calderas on the plateau d’Azrou (HARMAND & CANTAGREL, 1984; HARMAND & MOUKADIRI, 1986). K-Ar Age of these basalts ranges between 0.6 and 1.8 Ma (EL AZZAB & EL WARTITI, 1998), but the fresh landforms suggest an even younger age for some of these volcanoes.

3. – GEOMORPHOLOGY

The overall geomorphology of the Middle Atlas Causses is the product of a combination of mostly inherited and some active landforms.

The topography of the summits of the Causses designates an important palaeo-surface (denudation plain) that has been dated back to Eocene. This testifies a long period of tectonic stability, with the Eocene sea submerging most of the Mesozoic carbonates. Subsequently tectonic activity reactivated during Oligocene and dislocated the different plateaus of the Causses. Another period of tectonic stability occurred during Middle Miocene producing another denudation plain that did however leave the higher summits and the Eocene palaeo-surface in place (MARTIN, 1981). During this continental period karst corrosion processes begin to play an important role.

During Late Miocene-Pliocene erosion processes start building up the present landscapes, with the slow uplift of the Causses and the formation of the Northern and Western tectonic escarpments: the first clearly divides the Saïss plain and Rif from the Middle Atlas Causses while the second separates the Causses from the Palaeozoic outcrops (BEAUDET & MARTIN, 1967).

The presence of important deposits of travertines in the Saïss plain and along the north-western border of the Causses testifies important karst corrosion of the Liassic dolo- and limestones during this period. Erosion processes accelerate with the rapid incision of the Oued Sebou gorge on the Pliocene-Quaternary boundary leading to the final shaping of the present landforms and landscapes.

During Quaternary this landscape is disrupted by volcanic activity that give rise to several edifices and lava flows. The volcanic landforms appear very fresh and unaltered, especially on the Azrou plain, and comprise lava flows (pahoehoe lava), lava tubes, hornitos, spatter cones, caldera, explosion craters etc. The fact that these lava flows cover a karst topography has led to a convergence of forms with big collapse cryptokarstic dolines sometimes due to the presence of underlying lava tubes, but generally related to the collapse in depth of karst tunnels in limestones of Lias (MARTIN, 1981).

The present landscape of the Causses is disseminated with more or less active karst landforms, mainly present on the dolo- and limestone outcrops at different altitudes, but minor forms
have also been observed in the Palaeozoic marbles of the Tizra hogback. Many of the bigger landforms, such as poljes, macrodolines and uvalas, are related to the intense karst phases of Mio-Pliocene and are now almost completely inactive. They are generally located in structurally favourable areas such as intersection of faults or synclines. Some of these (Dayet Ifrah, Aguelmam Azizga etc.) still contain temporary lakes but lack springs and ponors. Their base level, very close to the aquifer, is slowly filling up with sediments and corrosion is no more active on their bottoms and their flanks.

The very large macrodolines such as Motfer-raoun (1.5 km wide and 110 m deep) and Trou de la Panthère are big collapse structures in the Lower Trias dolostones that do not appear to be related to faults. Their origin is most probably due to the dissolution of salt in the underlying Trias, leading to relatively fast collapse (El KHALKI & AKDIM, 2001; MARTIN, 1981).

The same dolostones display a wide variety of ruin-like forms, creating strange landscapes of rocky mushrooms, pinnacles and towers of several meters high, cut by rectilinear troughs and trenches. Very beautiful examples are located at Tidrine, near Ifrane, and at Tisfoula, along the road to the springs of Oum-Er-Rbia.

Karren landforms are widely represented especially in the dolostone facies in association with these ruin-like landforms, but also occur in limestones of the Causses and in the marbles of Tizra. In some places, at high altitudes and on the northern slopes, their rounded forms probably reflect their corrosion under snow or beneath a soil cover. Besides all kinds of normal and rounded clints also solution pans (kamenitze) are well represented.

The influence of snow on the karst forms is also well displayed above 1,700 m of altitude in the asymmetric shape of the dolines, with a preferential dissolution of their protected inner slopes. A similar phenomenon also occurs in the High Atlas karst of Ait Abdi (PERRITAZ, 1996).

Despite the well developed surface karst only few caves are known in the Middle Atlas mountains. This is due to the scarceness of thick pure limestone beds, often intercalated with marly limestones, and the abundance of highly fractured dolostones that convey surface waters directly to the underlying Trias through cracks and fissures (MARTIN, 1981). One of the best examples of true karst caves is Ifri-ou-Berrid, a sinkhole located at the end of a blind valley and with an underground development of approximately 100 meters, ending in a drowned passage.

Landscape development during Quaternary is characterised by the mechanical and chemical cutting of valleys during the wetter periods and the deposition of travertines and alluvial sediments during periods with diminished flow rate and higher temperatures. Now these valleys are mostly dry, except from the ones fed by springs (e.g. Oum-Er-Rbia) and are the relict of the drainage network of the pluvial periods.

Present morphodynamics is mainly correlated to karst denudation processes, weathering of the alkaline basalts and slope dynamics (especially on soft rock-types, e.g. Triassic marls and altered dolerites), enhanced by heavy sheep-breeding activities, with formation of badlands, gullies, creep and solifluction phenomena etc.

4. – METHODS

The adopted methodology is based on the experience acquired during the past couple of years in two National Research Projects (PRIN 2001-2003 on Geosites in the Italian Landscape and PRIN 2004-2006 on Geotourism in Italy) and especially during a Co-operation Project, financed by the Sardinian Regional Government, in which our team has collaborated with the Institute des Regions Arides of Medenine (Tunisia) aiming to define the geological heritage of the region of Tozeur in South Tunisia (De Waele et alii, 2005b; Di GREGORIO et alii, 2002). This method is based on the preliminary consultation of scientific and geographic literature and topographical, geological and tourist maps that have lead to a first selection of sites and landscapes of geological and geomorphological interest. For this purpose the detailed and magnificent PhD work of Jacques Martin, presented in 1977 at the Université de Paris VII (MARTIN, 1981), has been of enormous value, giving lots of suggestions on sites and landscapes of possible geo-tourist attraction.

Several field campaigns have been organised to study more in detail the selected geosites and geomorphosites, to verify the collected bibliographical data and to make detailed observations and gather further documentation (e.g. geological sketches, geomorphological processes, photographs). During these trips several other geomorphosites, previously ignored, have been added to the list and have also been studied in detail.

For the description of these sites in the field a sheet file has been compiled in which, together with the data of identification of the site (e.g. commune, locality, co-ordinates, altitude) also data on accessibility, visibility, geology and geomorphology, use and state of conservation are reported. Contents of such a sheet file, similar to the one adopted by our research team in Tunisia, is reported in figure 3.
For the identification, classification and the graphical representation of the geomorphosites a Landsat ETM+ Image has been used. The different lithological units outcropping in the area have been recognised by means of the creation of interpretation keys based on field surveys using the medium-infrared band combinations. Lithology, tectonics, drainage pattern, land cover and topography have then been analysed to characterise the general morphology of the study area. The use of satellite images has proven to be an ideal instrument for the recognition of the main landforms, guiding the field campaigns in a remarkable way. Where the vegetation is lacking or relatively scarce the spectral response of the different lithologies can easily be observed, while the distinction of topography has been enhanced introducing shadow analysis. Directional filters associated with spectral analysis have allowed to recognise the general structure of the area and the most important faults and alignments.

All the bibliographical, field and remote sensing data have been summarised in a geomorphological map superimposed on the satellite image (fig. 4).

The next step was to define the different landscape units based on a complex geomorphological and environmental analysis of the different parts of the study area. This landscape analysis allows to subdivide the territory in homogeneous units, differing in morphology, lithology or land-use and classified according to a hierarchical scheme.

Subsequently, the singles sites have been positioned on the satellite image and the links between the single geomorphosites and geosites (intrinsic values) and the surrounding landscape (overall value) have been defined in order to have a complete perception of the importance of geological heritage in the region.

This applied geomorphological interpretation of the Middle Atlas of Ifrane-Azrou allows to summarise the geological and geomorphological heritage of the area in which the single sites, because of their easy perception (recognisability), their characteristic form (completeness), their state of conservation (exemplarity) and their effective possibility of visit (accessibility) (Poli, 2003), are integrated in a global landscape and constitute the foundation for a sustainable geotouristic development. For a more direct understanding of this geomorphological heritage the geomorphosites and geosites are grouped in networks, according to similar geomorphological processes and differentiated by colours. This distinction in thematic networks of geosites and geomorphosites makes it also easier to define coherent actions of planning, valorisation and conservation.

5. – LANDSCAPE UNITS

Landscape units are territorial ambiits with specific, distinctive and homogeneous characteristics regarding their genesis, constitution and evolution due to both natural and human interactions (Bertrand, 1970; Di Gregorio, 1987; Romani, 1986). In general a Landscape Unit is a geographically distinct portion of an area that has a particular visual character.

The identification of the single Landscape Units has been carried out by means of the analysis and the classification of a complex series of characterising and significant elements (geological constitution, geomorphological elements, altitude, climate and microclimate and other physical and geographical elements, vegetation, material expressions of the human presence etc.). These elements also allow to define the originality, the scientific interest and the perceptive quality of the landscape according to the European Landscape Convention (ECC Treaty no 176, October 20th 2000) (Di Gregorio, 2003).
This subdivision of the study area in Landscape Units allows to:
- construct a territorial matrix useful as a spatial reference for the identified elements (natural sites, cultural heritage, human settlements and infrastructures, vegetation etc.);
- to interconnect in an organic way the different components in categories, classes and types and to better understand the relationships between the single sites and the surrounding landscape;
- to describe the determinant characters of more or less extensive homogeneous areas;
- to classify, plan and manage together the single components of the landscape, orienting the actions and interventions towards a shared goal – conservation or transformation – respecting the principles of sustainability.

The subdivision of the Ifrane-Azrou region in Landscape Units has been carried out using several types of thematic maps (topographical, geological, geomorphological) at different scales (from 1:50,000 to 1:250,000), interpreting aerial photographs and satellite images (Landsat ETM+) and carrying out surveys and controls in the field. Landscape units differ in terms of geomorphology, with different landforms in relation with the geological and structural settings, and land-use. Sheep-breeding is abundant on the steep slopes, on the Causses and on the basaltic plateaus while agriculture characterises the lower plains where irrigation is practiced since a long time. The recognised Landscape Units could be subdivided in smaller landscape facies with a detailed analysis at larger scales (TRICART & KILIAN, 1985), according to different natural and/or human components. Several Landscape Units can also be
grouped together to form Landscape Systems that describe the territory in a much more general but nevertheless characterising way. In the study area a total of five Landscape Systems have been recognised: the carbonatic Causses, the sedimentary and agricultural Lower Plains, the Plio-Quaternary Volcanic landscape system, the Palaeozoic Central Massif and the Transitional systems. The landscape has then further been subdivided in fourteen easily recognisable different Landscape Units. The main characteristics of the Landscape Systems and Units are resumed in table 1.

6. – GEOSITES, GEOMORPHOSITES, LANDSCAPES AND ITINERARIES

A total of 42 sites of geological and/or geomorphological interest have been identified, studied and classified and represent the essential reference for the construction of the thematic itineraries (tab. 2). Geomorphosites have been classified according to their genesis in volcanic, dissolution karst, deposition karst, fluvial, structural and polygenetic landforms, at which two geobotanical sites have been added. The same genetic

<table>
<thead>
<tr>
<th>Landscape System (LS)</th>
<th>Acronym</th>
<th>Landscape Unit</th>
<th>Description (main characteristics)</th>
<th>General morphology</th>
<th>Main lithologies</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Causses</strong></td>
<td><strong>Pc</strong></td>
<td>Tabular Causses</td>
<td>Tabular carbonate plateaus (Causses) of El Hajeb, Immouzer, Ifrane, Guigou, Ain-Leuh</td>
<td>Sub-horizontal bedded dolo- and limestone plateaus with typical karst features</td>
<td>Liassic dolostones, dolomitic limestones &amp; limestones</td>
</tr>
<tr>
<td><strong>Pcp</strong></td>
<td></td>
<td>Slightly folded Causses</td>
<td>Folded Middle Atlas SE of Timahdite</td>
<td>Folded dolo- and limestone plateaus with karst features and cuestas</td>
<td>Liassic dolostones &amp; limestones</td>
</tr>
<tr>
<td><strong>Pca</strong></td>
<td><strong>Caussed’Agourai</strong></td>
<td></td>
<td>Slightly NW-tilted carbonate plateau</td>
<td></td>
<td>Liassic dolostones &amp; limestones</td>
</tr>
<tr>
<td><strong>Ps</strong></td>
<td><strong>Timahdite (Bekrite) Syncline</strong></td>
<td></td>
<td>Large syncline with Cretaceous core and basalt infilling</td>
<td></td>
<td>Cretaceous limestones and Plio-Pleist. basalts</td>
</tr>
<tr>
<td><strong>Pt</strong></td>
<td><strong>Timahdite balcony</strong></td>
<td></td>
<td>Eocene limestone plateau of Timahdite</td>
<td>Eocene limestone balcony eroded by Oued</td>
<td>Eocene limestones</td>
</tr>
<tr>
<td><strong>Lower Plains</strong></td>
<td><strong>Ptq</strong></td>
<td>Saïss plain</td>
<td>Low plains N of Middle Atlas Causses</td>
<td>Agricultural plains and human landscape with the cities of Fès and Meknès</td>
<td>Plio-Quat. lacustrine sediments</td>
</tr>
<tr>
<td><strong>Volcanic</strong></td>
<td><strong>Pv</strong></td>
<td>Lavaflows</td>
<td>Plio-Pleistocene lava flows</td>
<td>Lava flows up to 40 km long</td>
<td>Plio.Quaternary basalts</td>
</tr>
<tr>
<td><strong>Pv</strong></td>
<td></td>
<td>Volcanic plateau</td>
<td>Plateau d’Azrou</td>
<td>Plateau basalt with various types of volcanoes</td>
<td>Plio.Quaternary basalts</td>
</tr>
<tr>
<td><strong>Pv</strong></td>
<td></td>
<td>Single volcanoes</td>
<td>El Koudiate, Jbel Outgui</td>
<td>Single volcanoes</td>
<td>Plio.Quaternary basalts</td>
</tr>
<tr>
<td><strong>Central Massif</strong></td>
<td><strong>Pes</strong></td>
<td>Structural landscape</td>
<td>Wide lower complex plain W of Causses d’El Hajeb</td>
<td>Hogbacks and syncline valleys</td>
<td>Palaeozoic marbles and quartzites</td>
</tr>
<tr>
<td><strong>Ped</strong></td>
<td></td>
<td>Hills with dendritic drainage</td>
<td>Azrou plain</td>
<td>Smooth and rounded hills in mostly tender rocks</td>
<td>Palaeozoic shales and phyllites</td>
</tr>
<tr>
<td><strong>Pev</strong></td>
<td></td>
<td>Reddish altered slopes</td>
<td>Western border of the Causses d’Agourai, El Hajeb &amp; Ain-Leuh</td>
<td>Concave slopes in tender rocktypes</td>
<td>Triassic sandstones, clays &amp; altered basalts</td>
</tr>
<tr>
<td><strong>Transitional systems</strong></td>
<td><strong>Pd</strong></td>
<td>Piedmonts</td>
<td>Slope deposits</td>
<td>More or less steep slopes</td>
<td>Plio-Quaternary slope debris</td>
</tr>
<tr>
<td><strong>Pdt</strong></td>
<td><strong>Travertines</strong></td>
<td></td>
<td>Travertine terraces and balconies along the borders of the Causses</td>
<td>Step-like travertine terraces or plateaus</td>
<td>Plio-Quaternary travertines</td>
</tr>
</tbody>
</table>

Tab. 1 – Landscape systems and units of the Azrou-Ifrane area and their main characteristics.

– Sistemi ed Unità di Paesaggio dell’area di Ifrane-Azrou e loro principali caratteristiche.
relationships have lead to the definition of the six itineraries that are based on genetic relationships between the different geomorphosites and exemplify the major genetic concepts of the landscape: volcanic, karst (dissolution and deposition), fluvial, structural and geobotanical.

The geomorphosites, in different colours according to their genetic relationships, the networks (grouping the geomorphosites of the same colours) and the landscape units are represented in the Geomorphosites Map of the region of Ifrane-Azrou, in scale 1:100.000. This map is the graphical summary and is the final product of this research. An extract of the Map is shown in figure 4.

This thematic map has been designed upon a Landsat ETM+ image and also reports infrastructural information (roads, villages etc.) and the main landforms and morphologies.

The geographical distribution of the geomorphosites in this map shows a greater concentration of sites of geomorphological and/or geological interest in the Landscape Units of the Tabular Causses (Pc) and on the volcanic Plateau d’Azrou (Pv). These

![Image of the Geomorphosites Map of the region of Ifrane-Azrou, in scale 1:100.000.](image-url)
Landscape Units are the ones with the greatest degree in Geodiversity (GRAY, 2003).

The six itineraries, reported in different colours, group the geomorphosites with similar genetic characteristics and have been given the following names: *La petite Auvergne* (small Auvergne), connecting 11 volcanic sites and named after the famous French volcanic region, *L’eau qui dissoud les roches* (the water that dissolves the rocks) grouping the 14 karst sites, *L’eau constructrice des roches* (the water that builds the rocks) comprising the 4 travertine sites, *L’eau constructrice des paysages* (the water that sculpts the landscapes) comprising 4 fluvial geomorphosites, *La Terre vivante* (the Living Earth) connecting 7 structural and tectonic landscapes and, finally, the 2 geobotanic sites. These networks have been reported in a miniature extract of the Map (bottom left) and reports, besides the geomorphosites (in different colours) also the landscape units and the road network. This extract is shown in figure 5.
For every itinerary a series of photographs of the most important geomorphosites with exhaustive explanations are given on the right side of the Map, two examples of which is given in figures 6 and 7.

7. - CONCLUSIONS

Research on geological and geomorphological sites is a completely new branch of earth science in Morocco, despite the fact that it is one of the most important North African countries for what concerns geology, geomorphology and landscape. Morocco, in fact, has both Atlantic and Mediterranean coastlines, several mountain chains (Rif, Middle Atlas, High Atlas, Anti-Atlas), a wide variety of ecosystems ranging from Mediterranean forests over high mountain meadows to plain deserts and plenty of other geo-ecosystems.

This paper is one of the first attempts of popularising geology and geomorphology to the local communities by means of a Geo-tourist Map that reports the essential sites of geomorphological sites and landscapes and also gives information on geology, geomorphology and geodiversity of the region of Ifrane and Azrou in the Middle Atlas. The Map, designed on a Landsat ETM+ image and written in French, describes this region in a scientific way but in the meantime uses a simple and direct language that has the purpose of bring-
ing also local people, unfamiliar with science, closer to the geological and geomorphological significance of the landscape in which they live. The Map is particularly designed for tourists, that often rush through this area in their travel to South Morocco, in the hope that they will decide to stay a while in the region to visit the geomorphosites suggested and described in the map. The use of photographs, showing the remarkable geological and geomorphological heritage of this region, is aimed to attract people to visit these sites.

The quantitative evaluation of the geological and geomorphological heritage of the region, following the guidelines proposed by several authors (Barca & Di Gregorio, 1991; Bruschi & Cendrero, 2005; Coratza & Giusti, 2005), in order to give a valuable tool for Environmental Impact Assessment studies (Bonachea et alii, 2005) could be a further development of this research.

Finally, it must be stressed that the implementation of tourist pressure on some of these geomorphosites, representing a logical consequence of the publication of geo-tourist maps such as the one presented in this paper, could compromise their integrity. Therefore it is becoming increasingly important to inform the local population and especially the local stakeholders that manage the geomorphological heritage in order to raise awareness on the uniqueness of their landscape and the geosites and geomorphosites contained in it. The understanding that this heritage is an important part of the cultural identity of their territory (Panizza, 2003) should make conservation and valorisation much easier.

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