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THE GEOMORPHOLOGY OF THE DOLOMITES FROM A GEOMORPHODIVERSITY VIEWPOINT

ABSTRACT: PANIZZA M., *The geomorphology of the dolomites from a geomorphodiversity viewpoint.* (IT ISSN 0391-9838, 2011).

After recalling the concept of *geomorphodiversity*, which was introduced by the Author in 2009, the peculiarities of the geomorphodiversity of the Dolomites are described.

First of all they have specific geomorphological and landscape characteristics which distinguish them from all other mountains in the world: i.e., they have greatly accentuated extrinsic geomorphodiversity on a global scale. On a regional scale and in relation to morphostructural landforms, the Dolomites have a high degree of extrinsic geomorphodiversity compared with other alpine mountains in relation to morphotectodynamics, morphotectostatics and morpholithology. They also have greatly accentuated intrinsic geomorphodiversity on a regional scale from the morphoclimatic viewpoint, considering their polygenesis linked to pre- or inter-glacial, glacial, periglacial, fluvial, relict, dormant or active landforms.

Nevertheless, when some geomorphological features, chosen with a subjective criterion, are examined in detail on a regional scale (for example talus cones or scree slopes), they show a limited intrinsic geomorphodiversity; whereas in other cases (as for landslides) they have a great intrinsic geomorphodiversity. Another example is offered by karst areas: they display in detail a vast array of landforms, that is considerable intrinsic geomorphodiversity on a local scale.

For all these reasons the Dolomites make up an important geoheritage that can be considered as a high-altitude field laboratory for research and development of geomorphological theories and understanding.

Finally the Author stresses that on June 26th 2009 the Dolomites were included in the World Heritage List because of their scientific importance from the geological and geomorphological point of view, together with their exceptional beauty and unique landscape. Furthermore, this inclusion is an important scientific goal and an event which stimulates in-depth studies, discussions and assessment of investigations and theories in the field of Geomorphology.

KEY WORDS: Geomorphology, Geomorphodiversity, Geoheritage, Dolomites, UNESCO.

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GEOMORPHOLOGICAL SETTING

The area of the Dolomites is part of the «Southern Alps», in the north-eastern area of Italy: it broadly stretches between the «Giudicarie tectonic line» and the «Pusteria tectonic line»; to the south and south-east it is bounded by the «Venetian and Friuli Pre-Alps» and to the east by the upper part of the Cellina valley, in the Carnia Dolomites (fig. 1).

The landscape and geomorphological features of this region have been created mostly by dolomite rocks (fig. 2) and partially by a wide array of other rock types, such as limestones, sandstones, porphyry, clay shales etc. (see Gianolla & *alii*, 2008). The rocks range in age from the Palaeozoic to the Cretaceous. The geological importance of the Dolomites is due to the extremely detailed and continuous manner in which they represent a large part of the Mesozoic Era, bearing witness to a tropical sea which existed here between 260 and 200 million years ago. It is

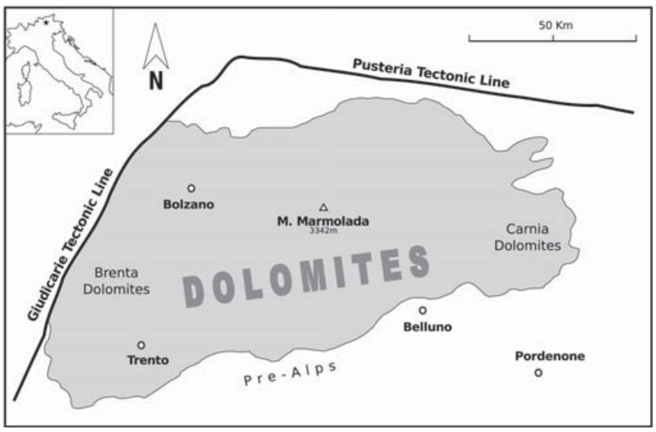

FIG. 1 - Location of the Dolomites.

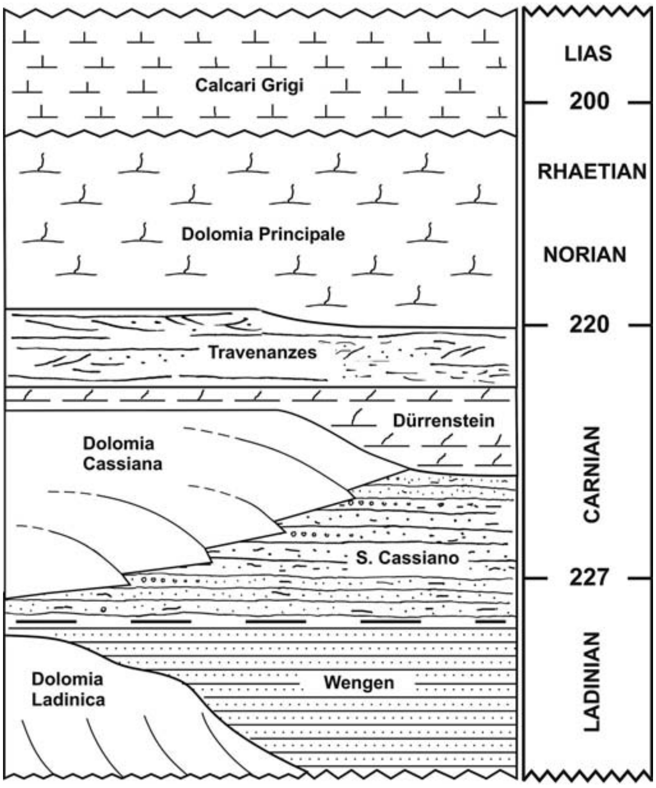

FIG. 2 - Schematic stratigraphic column showing the Upper Trias dolomite formations. Thickness is not at scale; numbers indicate millions of years ago.

possible to reconstruct the geo-history of this period as if reading from the pages of a gigantic stone book, walking on ancient lagoons and visiting the margin with the remains of coral and sponges before descending the age-old slopes to reach the bottom of ancient oceans. You can map out the succession of ancient cliff faces in space and time, or assist at volcanic eruptions and discover the evolution of various forms of life from shellfish to dinosaurs.

From the geomorphological standpoint the landforms took place in different ways and with different rhythms, also in relation with diastrophism activities, climate changes and human works: dolomite and calcareous towers, crests, pinnacles and escarpments; ranges and ridges of volcanic rock, hollows in clayey soils, folded, faulted and twisted layers, talus cones and scree slopes, plateaus and small lakes, colours and shapes, light and shadow: their history is ancient, complex and fascinating. In the collective imagery the Dolomites are considered as spectacular geoheritage, a natural work of art. From the Upper Miocene, when rocks emerged from the sea, meteoric water began to flow on the new reliefs and waves used to break on its coasts. Changes of temperature and humidity caused the physical and chemical weathering of rocks and the force of gravity, water and wind moved and redistributed debris. Depressions and valleys were formed in correspondence with outcrops of the weak rocks or with important tectonic displacements and related cataclastic belts. On the contrary, more resistant rock types, such as calcareous, dolomite or igneous rocks underwent a different morphogenetic evolution and gave origin to the highest mountain tops of the region. The morphogenesis is moreover linked to glacial, interglacial and up to present-day vicissitudes, with a vast array of exemplary landforms. In particular, several traces resulting from the last glacial expansion of the Upper Pleistocene (LGM) are found, both as erosion landforms and debris deposits. Among the former: glacial cirques, hanging valleys, «roches moutonnées». Among the latter: moraine deposits, also with erratic boulders. Numerous are the examples of periglacial and gravitational morphologies (rock glaciers, protalus ramparts, scree slopes, talus cones, landslides etc.), or of fluvial morphologies (gorges, terraces, alluvial fans etc.).

DEFINITION OF GEOMORPHODIVERSITY

The concept of *geomorphodiversity* has been introduced by Panizza (2009a): «the critical and specific assessment of the geomorphological features of a territory, by comparing them in an extrinsic and intrinsic way, taking into account the scale of investigation, the purpose of the research and the level of scientific quality».

It is derived from the concept of *geodiversity*, that first appeared in Australia (especially in Tasmania) in 1991 (Sharples, 1995) and received wide recognition, even if it was not always unanimously defined and in some cases showed a certain ambiguity (see: Panizza & Piacente, 2008 and 2009; Panizza, 2009a, Reynard & *alii*, 2009). It should be noted that the two concepts are very complex to apply in the field of research. Indeed, it is not sufficient to summarise the geomorphological characteristics of a given territory, maybe using mathematical indexes or formulas, since research would be reduced to a mere statistical elaboration of data which, in most cases, had been previously collected.

On the contrary, the concept of geomorphodiversity could be based on the identification of the geomorphological elements, which characterize the landscape of a territory, independently of their frequency or spatial distribution. On the other hand, it should not even indicate the variety and multiplicity of the geomorphological elements of a region, since this would make it coincide with its «*geomorphological complexity*». It should instead refer to a specific peculiarity which makes it *different* from other landscapes, on the basis of type, scale and level of this new concept of geomorphodiversity.

This concept cannot be univocal: the whole set of all geomorphological data of the study area should be critically assessed, by comparing them with each other (in an intrinsic way) and with those from other areas (in an extrinsic way), in order to evaluate their specificity and therefore their geomorphodiversity. The scale of the investigations should be taken into the right account and the level of their scientific quality assessed. A proper choice of the geomorphological elements to be examined and evaluated in a specific way, in particular for applied purposes, might be important. Practically, it is a matter of carrying out original research, finalised each time towards well-defined goals, by avoiding statistical elaborations which are only an end in themselves.

THE GEOMORPHODIVERSITY OF THE DOLOMITES

With reference to the above defined concepts, the various types of high-level geomorphodiversity in the Dolomites, at different scales of representation (fig. 3), can now be illustrated.

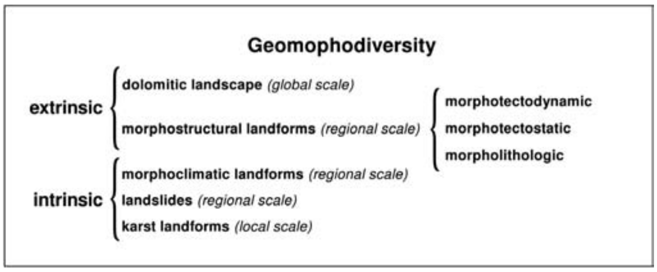

FIG. 3 - Scheme of the various types of high-level geomorphodiversity in the Dolomites, at different scales of research.

Firstly they have greatly accentuated *extrinsic geomorphodiversity* on a *global scale*, that is monumental, original and spectacular specific geomorphological characteristics distinguishing them from all other mountains in the world (fig. 4). It is here that 19th century travellers found inspiration for the «romantic» landscape (fig. 5), and they still provide a fundamental reference point for defining the modern concept of natural beauty. We should remember the painters who have been inspired by these mountains for their works: from Titian to the romantics, from the expressionists to the futurists and onwards to contemporary artists, in addition to writers, poets… and other artists who have felt stimulated and called to immortalise the aesthetic suggestions of these mountains.

Moreover the Dolomites, compared with other alpine mountains on a *regional scale* and in relation to morphostructural landforms, have a high degree of *extrinsic geomorphodiversity.* In fact if they are to be compared with other carbonate mountains of the Alps bearing the same name, such as the «Lienzer and Salzburgen Dolomiten» (Austria) and the «Dolomites françaises» (Vercors, France), the result is that the Italian Dolomites are found to be far superior, owing to their matchless variety and exemplarity of structural landforms. The same is true if they are compared with other carbonates platforms in Europe and in the world, such as the «Asturias» (Spain), Hydra Island (Greece), Crimea (Ukraine), Pilot Mountains (Nevada, USA), «Canning Basin» (Australia) and many more (see: Gianolla & *alii*, 2008).

In particular, with respect to *morphotectodynamics*, the Dolomites have a high relief energy, because they are located within the belt of Alpine orogenesis, with considerable variation in height between mountain tops and valley floors. Besides there is evidence of active or recent tectonics with fault planes and scarps, stream cuts, fluvial el-

FIG. 4 - In the forefront Croda da Lago and, behind, Becco di Mezzodì, both made up of Norian dolostones and dissected into towers, crests and pinnacles along tectonic fractures: examples of high extrinsic geomorphodiversity on a regional scale (morphotectostatic). In the background Mt. Pelmo, made up of «Dolomia Principale» and «Calcari Grigi» formations: example of a landscape with high extrinsic geomorphodiversity on a global scale. The foot of Croda da Lago is covered by talus cones and scree slopes: example of low intrinsic geomorphodiversity on a regional scale (morphoclimatic). Photo M. Price.

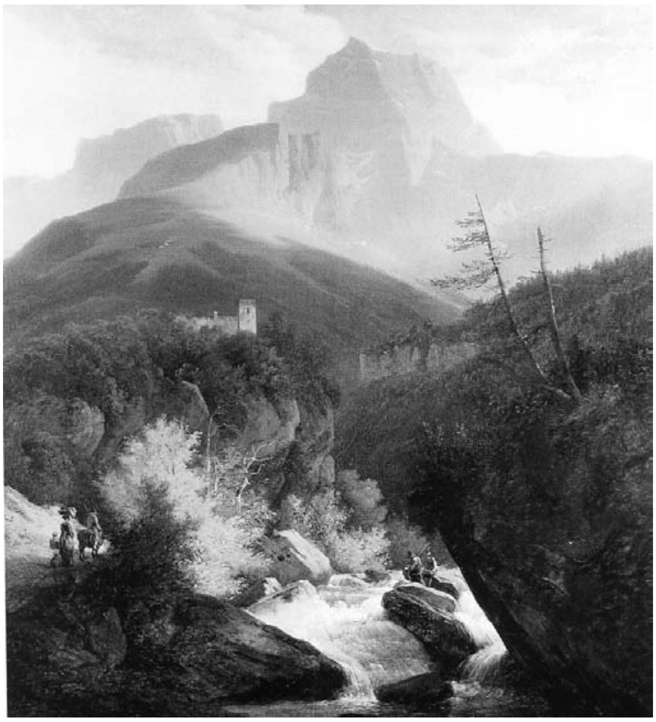

FIG. 5 - Landscape in the Dolomites: example of high extrinsic geomorphodiversity on a global scale. Oil on canvas by F. Diday (1802-1877).

bows, saddles, crest displacements etc. Evident examples are found in the upper Val Badia (Panizza & *alii*, 1978; Corsini & Panizza, 2003) or in the mid-Val di Fassa (Panizza & *alii*, 1978); particular evidences of links between neotectonics, erosional, sedimentary and pedogenetic processes can also be observed, as at Col Bechei, in Fanes Dolomites (Panizza & Dibona, 1990).

With regard to *morphotectostatics,* the most typical landscape is that of dolomite peaks sculpted along fractures in the form of towers, steeples, crests and pinnacles, as, for example, at Tre Cime di Lavaredo, Cime di Fanis, Croda da Lago (fig. 4) and Cinque Torri. Moreover, the arrangement of the main valleys, the location of some passes and saddles and the position of some of the most sheer and majestic rock walls are determined by the trends of important displacement lines as in the case of Vallonga, Travenanzes (fig. 6), Funes, Tires, Cismon or San Vigilio valleys. In addition, the presence of overthrusts has caused the formation of saddles, like those of Valparola Pass and Falzarego Pass. Furthermore, the attitude of layers in relation to the aspect of slopes has considerably influenced slope gradients, as for example in the Lastoni di Formin. The tabular morphology of several Dolomite plateaus is in most cases related to the horizontal top of Mesozoic shelves, as in Rosetta (fig. 7), Gardenaccia or Alpe di Fanes. An example of relief form resulting from tectonic folds is Cima Bocche, between the San Pellegrino Pass and Valles Pass: this is an anticline fold which has affected geological formations from the Permian to the Anisian and appears partially eroded along its axial direction.

With regard to *Morpholithology,* the great variety of rock formations generates a series of selective-type relief forms, like some passes or saddles or steep walls and sheer peaks. In many cases compact rock types alternate with weaker ones or with rocks of different origin (sedimentary and igneous) or the proximity of rocks with different compositions have all created varied and contrasting morphol-

FIG. 6 - Val Travenanzes, set along a fault line, between Tofane (on the right) and Cime di Fanes (on the left): example of high extrinsic geomorphodiversity on a regional scale (morphotectostatics). Tofane and Cime di Fanes (made up of «Dolomia Principale») are covered at their foot by talus cones and scree slopes: example of low intrinsic geomorphodiversity on a regional scale (morphoclimatic). Photo by M. Price.

FIG. 7 - Step-like glacial cirques at Pale di S. Martino (Ladinian dolomites): example of high intrinsic geomorphodiversity on a regional scale (morphoclimatic). In the forefront Rosetta plateau: example of high extrinsic geomorphodiversity on a regional scale (morphotectostatic) and of high intrinsic geomorphodiversity on a local scale (karst landforms). Photo by M. Price.

ogy (fig. 8), characterised by mild slopes, ledges, steps, steep rock walls or uniform mountain massifs. This is the case, for example, of the ledge of Sella Group, where the Upper-Carnian clay formation, interposed between mid-Carnian dolostones at the bottom and the Norian ones at the top, shows a low slope gradient in comparison with the sub-vertical dolomite walls. There are also characteristic and spectacular examples of carbonate inclined slopes of primary depositional origin which have not been influenced by tectonics. These are the original slopes which connected the top of the Mesozoic shelves with the floors of the proximal basins. These Triassic submarine shelf morphologies stand out in the neighbouring landscape, isolated by differential erosion of marly-clayey and pyroclastic rock types in the surrounding basins. Examples of these situations can be observed on the eastern wall of the Sciliar plateau, the eastern slope of Mt. Cernera and the north-western face of Pale di San Lucano.

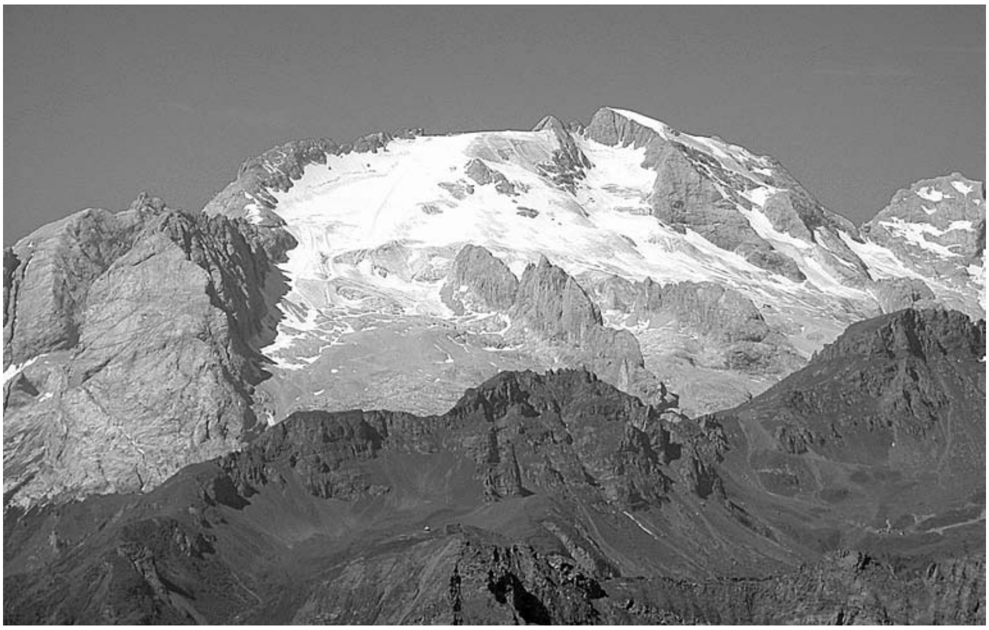

FIG. 8 - The Marmolada glacier, with the Padon range in the forefront. The morphological and colour contrast between the «Marmolada limestones» and the volcanoclastic rocks of Padon (both Ladinian) can be appreciated: example of high extrinsic geomorphodiversity on a regional scale (morpholithological). Photo by M. Panizza.

Climatic conditions directly influenced morphogenetic agents in the Dolomites. In fact they show a very complex geoheritage from the *morphoclimatic* viewpoint: the warm or temperate and humid environments of the pre-Pleistocene and the alternation of cold and temperate ones of the Pleistocene and Holocene have generated a sequence of different landforms modelled according to various processes (Castiglioni, 1964; Carton & Pelfini, 1988; Panizza, 1988; 1990, 2009a; Carton & Soldati, 1993). Therefore, they also have greatly accentuated *intrinsic geomorphodiversity* on a *regional scale*.

Pre-Pleistocene morphologies are some exhumed landforms and relict terraced surfaces (Panizza, 2009a). Rare interglacial deposits are recorded in the mid-valleys of Fassa and Gardena. Abundant reliable glacial morphologies are connected with the last Glacial period (LGM), when glaciers used to occupy all the Dolomite valleys, with ice thickness often exceeding 1500 m. They created a network of branches intersecting between one valley and another and some Dolomite passes acted as transfluence saddles. The most evident glacial landforms are: cirques (fig. 7), steps, hanging valleys and «roches moutonnées». There are also moraine deposits mainly ascribable to the Lateglacial phase, which started around 17,000 yrs BP. These are predominantly lateral moraines and frontal arcs. The latter have often caused valley barrages, with consequent formation of impoundments, such as Misurina Lake (Cristallo Group) and Carezza Lake (Latemar Group). Holocene glacial deposits are found mainly near the present glaciers, mostly in the form of lateral moraines. Some mountain groups still have ice masses today; the main ones are found in the following mountains: Marmolada (the largest one: fig. 8), Fradusta, Cristallo, Pelmo, Civetta, Pale di San Martino and Brenta. Also periglacial or fluvioglacial processes, linked to Pleistocene glacialism, have left many typical traces, such as permafrost and frost thrusting, cracking and sorting, terraced forms or lacustrine and palustrine depressions.

Moreover, if some categories of «geomorphological objects» are *subjectively* taken into account, as, for example, *landslides*, they show, still on a *regional scale*, a considerable complexity of types, causes, ages, lithology, movement, extent etc.; that is they have greatly accentuated *intrinsic geomorphodiversity*. In fact landslides are widespread in the Dolomites and mainly consist of mass movements occurring from the Lateglacial. Practically all the different types of landslides, as defined in international «classifications» (see Varnes, 1958), can be found in the Dolomites. Some of the most significant examples of the various landslide types are as follows: Mt. Pelmo (rock fall), Cinque Torri (rock topple), Vajont (rock slide), Corvara (earth slide), Mt. Faloria (rock flow), Fiames (debris flow), Lacedel (earth flow), Lastoni di Formin (rock spread). The frequency and magnitude of slope movements is proved to be very high in the last Post-glacial period. Panizza (1973) showed that many large-scale landslides are concentrated downstream of the confluence of glaciated valleys when slopes, affected by «glaciopressure» and no longer sustained by ice masses, collapsed. Among these mass movements the following can be quoted: Cima Rosetta, in Cismon valley, Mt. Faloria and Mt. Antelao, in Boite valley, and Mt. Ponsin, in Duron valley. The analysis of the dated mass movements has allowed correlations to be outlined between increases in landslides activity and climate changes in this region (Soldati & *alii*, 2004).

Furthermore, during the past few years there have been numerous falls and topples from over 2000 m high Dolomite peaks (Panizza, 2009b): in Gardena, Badia and Fiscalina valleys, at Odle, Tofane, Pomagagnon and Cinque Torri (fig. 9). This is the consequence of the thawing of permafrost trapped in the fossil state in gaps between

FIG. 9 - Broken up blocks of Torre Trephor (Cinque Torri), which toppled and fell in June 2004. Example of high intrinsic geomorphodiversity on a regional scale. Photo by M. Panizza.

the rock. The rising of summer temperatures has led to the thawing of part of this fossil ice. The gaps thus fill with thawed water, in addition to that coming from precipitation; during the following winter new ice forms in the same gaps, with an increase of around a tenth in the volume of water and the consequent widening of gaps; in the following summer these gaps are filled with an even larger amount of water, which then freezes again and further widens, deforms and ultimately breaks up the rock. Cycles of progressive freezing and thawing have created a greater tendency for portions of the rocks to break off, thus leading to collapse. In clayey sections, similar quantities of thawed water have instead made the rock more viscous, thus producing or reactivating slides or mudflows, as taking place on slopes overlooking various.

Another *subjective* example is offered by *karst* areas: they display in detail a vast array of landforms, that is, considerable *intrinsic geomorphodiversity* on a *local scale*. This surface and subsurface morphology is widespread, mainly in Rosetta (fig. 7), Sennes, Brenta, Vette Feltrine, San Lucano, Belluno and Brenta Dolomites. The most typical glacio-karst landforms are large depressions, blind valleys, dolines, karrens, «kamenitza»; pits and caves are widespread in Fanes, Fosses, Piani Eterni and Rosetta plateaus and in the Brenta Dolomites.

The geomorphological evolution we can observe today is linked to various causes: characteristics of the rocks and their structural discontinuity, current climatic conditions, more or less intense weather phenomena and human activities. One can note that the relict morphological features still condition to date morphodynamics; waterfalls with high erosional power plunge down from hanging valleys of glacial origin; moraine debris is repeatedly subject to degradation and collapse processes; the thawing of ancient permafrost can lead to landslides from new freezing-thawing processes (in compact rock) and water absorption (in clayey); the rocks broken up by frost-weathering are affected by debris falls which, in turn, generate debris flows; fluvioglacial terraces are the main sites of pedogenetic processes and situations of phyto-morpho-stasis; moraine arcs or kettle lakes and ponds show in some places representative morphostratigraphic sequences containing organic finds; the latter can be dated for paleo-geomorphological reconstructions.

CONCLUSIONS

When considered as a whole, these mountains offer an exceptional complexity of morphostructural and morphoclimatic landforms, even in the most minute details. In fact the aggregation of all these landforms, either relict, recent or active, has produced with time a geoheritage, that can be considered as a high-altitude field laboratory for research and development of geomorphological theories and understanding.

Even on the basis of the viewpoint here illustrated (*geomorphodiversity*), a Dossier for the inclusion of the Dolomites in the UNESCO World Heritage List was prepared. It was written out by tree experts: Cesare Micheletti for the natural beauty and aesthetic characteristics, Piero Gianolla for the geological contents and the undersigned Mario Panizza for the geomorphological features. Out of the Dolomite range, nine different «systems» were chosen to represent an organic «series» of exceptional aesthetic and scientific values. The nine systems, found in the provinces of Belluno, Bolzano, Pordenone, Trento and Udine and contained in an area of approximately 142,000 hectares, are integrated and complementary: in fact they constitute a serial property, as they represent a unified whole, albeit dislocated and complex, both in terms of geography and landscape and from a geological and geomorphological standpoint. The various Dolomite ranges are characterised by extraordinary representativeness and high levels of protection, and are linked through an extensive genetic and aesthetic network of relations; thus providing an overview of a group of extraordinary mountains, unique landscapes created from rocks and relief forms which tell the wonderful tale of a long interval in the history of the Earth and illustrate globally important geological and geomorphological processes.

On June 26th 2009 the Dolomites were included in the World Heritage List because of their exceptional beauty and unique landscape (criterion vii), together with their scientific importance from the geological and geomorphological viewpoint (criterion viii). In particular, with reference to criterion viii and Geomorphology, it was stated that «The Dolomites are of international significance for geomorphology, as the classic site for the development of mountains in dolomite limestone. The area presents a wide range of landforms related to erosion, tectonism and glaciation. The quantity and concentration of extremely varied carbonate formations is extraordinary in a global context, including peaks, towers, pinnacles and some of the highest vertical rock walls in the world. …(*omission*)… Taken together, the combination of geomorphological and geological values creates a property of global significance».

Finally, the inclusion of the Dolomites in the UNESCO World Heritage List is an important scientific goal, owing mainly to their geomorphological importance. This event has also provided an incentive for studying in-depth, discussing and assessing investigations, results and theories in the field of Geomorphology.

REFERENCES

CARTON A. & PELFINI M. (1988) - *Forme del paesaggio d'alta montagna.* Scuola di Montagna, 5. Zanichelli, Bologna, 136 pp.

CARTON A. & SOLDATI M. (1993) - *Geomorphological features of the Dolomites (Italy).* In: Panizza M., Soldati M., Barani D. (eds.), «First Europ. Intens. Course on Applied Geomorphology». Proceedings, Università di Modena, 13-29.

CASTIGLIONI G.B. (1964) - *Sul morenico stadiale delle Dolomiti.* Memorie Istituto Geologia e Mineralogia, Università di Padova, 24, 16 pp.

CORSINI A. & PANIZZA M. (2003) - *Conseguenze geomorfologiche di una faglia neotettonica nell'Alta Val Badìa (Dolomiti).* In: Biancotti A. & Motta M. (ed.), «Risposta dei processi geomorfologici alle variazioni ambientali», MURST - COFIN, Brigati, Genova, 173-176.

GIANOLLA P., MICHELETTI C. & PANIZZA M. (2008) - *Nomination of the Dolomites for inscription on the World Natural Heritage List UNESCO.* Dolomiti, Belluno, 1, 363 pp.

PANIZZA M. (1973) - *Glacio Pressure implicatons in the production of Landslides in the Dolomitic area*. Geologia Applicata e Idrogeologia, 8(1), 289-297.

PANIZZA M. (1988) - *Geomorfologia*. In: Panizza M. (ed.), «Guide naturalistiche delle Dolomiti venete», vol. 1, Dolomiti, S. Vito di Cadore, 43-54.

PANIZZA M. (1990) - *Il fascino e le vicende della storia geomorfologica delle Dolomiti.* In: Comunità Montana Agordina, «Le Dolomiti un patrimonio da tutelare e amministrare», 19-31.

PANIZZA M. (2009a) - *The Geomorphodiversity of the Dolomites (Italy): a key of Geoheritage assessment*. Geoheritage, 1, 33-42.

PANIZZA M. (2009b) - *Geomorphodiversity of the Dolomites and some remarks on recent rock falls.* In: Malet J.-P., Remaitre A. & Bogaard T. (eds.), «Landslides processes, from geomorphological mapping to dynamic modelling», CERG Editions, Strasbourg, 356 pp.

PANIZZA M., CARTON A., CASTALDINI D., MANTOVANI F. & SPINA R. (1978) - *Esempi di morfoneotettonica nelle Dolomiti occidentali e nell'Appennino modenese*. Geografia Fisica e Dinamica Quaternaria, 1, 28-54.

PANIZZA M. & DIBONA D. (1990) - *Segnalazione di un suolo presso il Col Bechei (Dolomiti di Fanes) e suo possibile significato neotettonico.* Il Quaternario, 3, 31-38.

PANIZZA M. & PIACENTE S. (2008) - *La geodiversità e una sua applicazione nel territorio emiliano*. Il Geologo dell'Emilia-Romagna, 8, 29, 35-37.

PANIZZA M. & PIACENTE S. (2009) - *Cultural geomorphology and geodiversity*. In: Reynard E., Coratza P. & Regolini-Bissig G., (eds.), «Geomorphosites». Verlag F. Pfeil, München, 35-48.

REYNARD E., CORATZA P. & REGOLINI-BISSIG G., eds. (2009) - *Geomorphosites*. Verlag F. Pfeil, München, 240 pp.

SHARPLES C. (1995) - *Geoconservation in forest management-principles and procedures*. Tastforest, Hobart, 7, 37-50.

SOLDATI M., CORSINI A. & PASUTO A. (2004) - *Landslides and climate change in the Italian Dolomites since the Lateglacial.* Catena, 55(2), 141-161.

VARNES D.J. (1958) - *Landslides types and processes.* In: Eckel E.B. (ed.), «Landslides and engineering practice», Highway Research Board Special Report, 29, 20-47.

(Ms. received 1 January 2010; accepted 1 January 2011)