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Il catasto delle aree carsiche d'Italia

The register of the italian karst areas

PICCINI L. (*)

RIASSUNTO – Negli ultimi anni la Società Speleologica Italiana (S.S.I.) sta portando avanti un progetto per la realizzazione di un catasto nazionale delle aree carsiche.
Le aree carsiche rappresentano ambienti di notevole interesse per diverse ragioni:

1) gli acquiferi carsici contengono importanti risorse idriche, spesso di ottima qualità poiché le aree carsiche hanno normalmente una pressione antropica modesta;

2) i paesaggi carsici sono particolarmente conservativi, da un punto di vista morfologico, per questo in essi è possibile trovare le tracce dei principali cambiamenti ambientali del passato;

3) gli ambienti carsici ospitano spesso importanti biotopi con specie endemiche e specie relitte, il che li rende zone di elevato pregio ambientale.

Per area carsica si intende normalmente un particolare tipo di paesaggio dove le forme generate da processi di dissoluzione delle rocce prevalgono su altri tipi di forme superficiali; nei climi temperati questo accade normalmente dove affiorano rocce calcaree, dolomitiche o gessose. I parametri morfologici non sembrano comunque essere i migliori per la definitione di area carsica; infatti tipiche forme carsiche, come karren, doline e grotte possono formarsi anche in seguito a processi non carsici e su rocce diverse da quelle carbonatiche e gessose. Per queste ragioni le moderne definizioni di ambiente carsico seguono maggiormente criteri di tipo idrogeologico anzichè morfologico.

In base a questi princìpi il catasto delle aree carsiche d'Italia segue i seguenti criteri:

– *litologia* - nel territorio italiano troviamo sempre ambienti carsici in corrispondenza dei principali affioramenti di rocce calcaree e gessose. Gli affioramenti di rocce a minor solubilità, dolomie e calcari impuri, possono essere considerati come aree carsiche quando sono presenti caratteri idrogeologici e morfologici carsici;

– *idrogeologia* - si basa sulla presenza di un assetto idrogeologico di tipo carsico con un drenaggio sotterraneo elevato che alimenta grosse sorgenti carsiche;

– *morfologia* - si basa sulla presenza di tipiche forme carsiche di dissoluzione come karren, doline e sistemi di grotte.

PAROLE CHIAVE: ambienti carsici, censimenti, risorse naturali.

ABSTRACT – During the last years the Italian Speleological Society (S.S.I.) has carried out a project for the realisation of a national register of karst areas. The importance of this archive is easily understandable. In Italy, karst areas cover almost 20% of the whole territory; not including the alluvial plains, the percentage grow up to about 50%.

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Karst areas represent an important environment for various reasons:

1) karst aquifers contain the most important water resources of mountainous countries; these resources have often a good quality because karst areas have currently a low anthropic pressure;

2) karst landscapes are very conservative because the geomorphic action of runoff water is very low. Moreover in karst areas we find underground systems of caves: these probably are the most conservative environments of the earth surface; in them we can find the records of the main environmental changes that occurred during the evolution of deep karst;

3) in karst environments we often find important biothopes with endemic and relict species.

"Karst" is currently call a particular kind of landscape where landforms due to solution processes are prevailing on other kinds of landforms. In temperate countries this normally occurs on outcroppings of limestone, dolomite or gypsum.

Anyway morphological parameters don't seem to be the best criteria for the definition of a karst area. In fact typical karst landforms such as karren, dolines and caves can be formed also by non-karstic processes and on rocks different from the carbonate ones and gypsum. For these reasons modern definitions of karst environment follow more hydrogeologic criteria than morphologic ones.

According to these principles the register of karst areas of Italy is following these criteria for the individuation of a karst area:

– *lythology* - in Italy we can always find karst environments where limestone or gypsum outcrop. The outcroppings of rocks of lower solubility, dolomite and impure limestone, can be considered as a "karst area" when the hydrogeologic and morphologic features of karst occur;.

– *hydrogeology* - based on the presence of a karst hydrogeologic setting, with a high underground drainage which feeds great springs;

– *morphology* - based on the presence of typical karst solution landforms such as karren, dolines and cave systems.

KEY WORDS: karst environments, inventories, natural resources.

1. – INTRODUZIONE

L'importanza ambientale delle aree carsiche è legata a diversi fattori.

In primo luogo occorre ricordare che gli acquiferi carsici contengono le più ingenti risorse idriche delle regioni montane, acque che vengono captate per soddisfare i fabbisogni idrici di grandi città; si pensi ad esempio a Roma, Napoli e Bari, per citarne alcune. Queste risorse sono spesso di ottima qualità poiché le aree carsiche, per le loro caratteristiche fisiografiche, hanno normalmente una pressione antropica modesta.

Motivi di interesse più strettamente scientifico derivano dal fatto che i paesaggi carsici sono, da un punto di vista geomorfologico, particolarmente conservativi, poichè l'azione modellatrice delle acque di ruscellamento è generalmente bassa. Si tratta probabilmente degli ambienti più conservativi della superficie terrestre; in essi è possibile trovare, più facilmente che altrove, le tracce dei principali cambiamenti ambientali che si sono succeduti durante l'evoluzione del carsismo. Questo succede soprattutto nelle grotte, che sono in grado di preservare le tracce di eventi geologici per tempi lunghi, al riparo dai processi morfogenetici di superficie.

Gli ambienti carsici, inoltre, per le loro caratteristiche fisiografiche peculiari e per il generale basso impatto antropico, ospitano spesso importanti biotopi con specie endemiche e specie relitte.

In generale possiamo affermare che le aree carsiche rappresentano assai frequentemente zone di elevato pregio ambientale. Non è un caso che in Italia, come altrove, la maggior parte delle aree protette ricada in aree carsiche: basti ricordare i grandi parchi nazionali delle Dolomiti, del Gran Sasso, della Maiella, di Abruzzo, del Pollino e del Golfo di Orosei, per citare i maggiori.

Questi ed altri motivi di interesse scientifico, naturalistico, applicativo e turistico rendono pertanto importante una conoscenza capillare di queste aree. Il primo passo è quello di individuare e catalogare le aree carsiche costituendo un catasto nazionale generale sintetico e dei catasti regionali con la documentazione completa.

In Italia archivi di questo genere assumono una particolare importanza poiché circa il 20% del territorio è costituito da aree carsiche; se consideriamo poi solo le aree montuose e collinari, tralasciando le pianure alluvionali, tale percentuale cresce sino a circa il 50%.

Nel 1986 la Società Speleologica Italiana (S.S.I.) elaborò una scheda di riferimento per la creazione di catasti regionali delle aree carsiche (MIETTO & SAURO, 1986, 1987). Lo scopo era quella di creare agili strumenti per la conoscenza del territorio e la gestione delle risorse ambientali di quelle aree che per le loro caratteristiche geologiche, morfologiche e idrogeologiche possono definirsi come aree carsiche.

Come già accadde per il catasto delle grotte, la scheda per il catasto delle aree carsiche non soddisfece tutte le esigenze delle singole regioni, alcune delle quali hanno provveduto a compilare catasti regionali con caratteristiche diverse (MIETTO, 1987, REGIONE LIGURIA, 1990). Attualmente solo alcune regioni, soprattutto del Nord Italia, hanno catasti ufficiali delle aree carsiche.

La diffusione dei personal computer e degli archivi informatici permette oggi di rilanciare il progetto di un catasto nazionale delle aree carsiche con caratteristiche di sistema informativo territoriale a scala nazionale. La realizzazione di tale sistema implica in primo luogo la definizione di cosa si intenda per area carsica.

2. – CRITERI PER LA DEFINIZIONE DI AREA CARSICA

La definizione di «area carsica» presuppone la definizione precisa del sostantivo «carsismo».

Le accezioni moderne del termine carsismo danno più importanza a fattori idrogeologici che non morfologici, nel tentativo di dare ai fenomeni carsici una connotazione il più possibile oggettiva e slegata da fattori di scala.

Una definizione moderna di area carsica, in accordo con quanto riportato da alcuni autori, potrebbe essere la seguente: un area geograficamente omogenea ove i processi carsici di degradazione chimica in acqua delle rocce e i processi fisici da essi indotti, hanno portato ad un assetto idrologico caratterizzato da un elevato coefficiente di infiltrazione e da una circolazione sotterranea organizzata con pochi punti di recapito.

Nelle situazioni ambientali in cui non vi siano in azione altri processi morfogenetici maggiormente attivi, i processi carsici portano nel tempo allo sviluppo di morfologie di superficie particolari che caratterizzano anche in senso fisiografico (morfologico) un'area carsica.

Nella prassi i criteri per la definizione di un'area carsica possono essere sostanzialmente tre: litologici, morfologici, idrogeologici.

2.1. – CRITERI LITOLOGICI

Per il tipo particolare di processi coinvolti le rocce più soggette al carsismo sono quelle a solubilità maggiore, ovvero quelle costituite prevalentemente da carbonati (calcari e dolomie), solfati (gessi) o alogenuri (salgemma). Non bisogna però dimenticare che tutte le rocce sono solubili, anche se alcune in misura minima, e in particolari condizioni ambientali la loro solubilità può essere tale da rendere i processi carsici predominanti su altri tipi di processi morfogenetici.

Alle nostre latitudini e con il nostro clima gli affioramenti delle rocce più solubili, calcari puri e gessi, presenteranno praticamente sempre fenomenologie carsiche tali da farli considerare come aree carsiche, mentre gli affioramenti di rocce meno solubili, dolomie e calcari impuri, potranno esserlo solo quando si riscontrano anche certi caratteri idrogeologici e/o morfologici. Solo in casi particolari avremo fenomenologie carsiche su rocce a solubilità molto bassa (es. graniti, silico-areniti, etc.).

Il criterio litologico, seppur validissimo come base di partenza (la individuazione delle aree carsiche partirà sempre dalla individuazione degli affioramenti delle rocce maggiormente solubili) non può comunque essere ritenuto come l'unico per il riconoscimento di un'area carsica.

2.2. – CRITERI MORFOLOGICI

Contrariamente a quanto avveniva in passato si è riscontrato che si deve dare minor importanza ai criteri morfologici, ovvero alla presenza o meno di morfologie considerate come tipiche delle aree carsiche: doline, karren, grotte, etc.

Forme anologhe a quelle carsiche possono infatti originarsi anche a partire da processi diversi (forme pseudocarsiche).

Inoltre i criteri morfologici sono maggiormente legati a scelte soggettive di scala. Ad esempio doline e grotte sono forme a cui vengono assegnati normalmente limiti dimensionali arbitrari che non hanno nessun riscontro genetico.

Non bisogna dimenticare che tra i caratteri morfologici rientra anche il maggiore o minore sviluppo di sistemi di cavità sotterranee, la cui esistenza ci è nota solo quando tali sistemi hanno accessi transitabili all'uomo, cosa questa che appare essere più l'eccezione che la regola.

2.3. – CRITERI IDROGEOLOGICI

Sembrano essere quelli più idonei a caratterizzare una area carsica e quelli che meglio si prestano alla definizione di una scala di grado di sviluppo del carsismo.

Coefficiente di infiltrazione, strutturazione e gerarchizzazione delle linee di drenaggio delle acque sotterranee, distribuzione e caratteri idrodinamici delle sorgenti, sono tutti parametri atti a caratterizzare in senso carsico un'area.

Rispetto agli acquiferi per porosità interstiziale o per sola fratturazione, gli acquiferi carsici presentano una maggiore anisotropia e una canalizzazione sotterranea in grado di sopportare flussi idrici di grossa portata in regime turbolento. Tutto ciò si riflette in un

comportamento idrodinamico generale ben diversificato da quello delle aree con carsismo assente o poco sviluppato.

3. – PROCEDURE PER LA INDIVIDUAZIONE DELLE AREE CARSICHE

Con l'uso di carte geologiche a scala medio-grande, cioè da 1:100.000 in sù, si individuano gli affioramenti di rocce cosiddette solubili, cioè le rocce con tenore di carbonati maggiore del 50% e i gessi, escludendo gli affioramenti di dimensioni troppo piccole, ad esempio quelli non riportati sulla cartografia 1:100.000, salvo casi particolari di aree piccole ma di notevole interesse ambientale.

Gli affioramenti di calcari ad alto tenore di $CaCO_3$ (maggiore del 80%) e quelli di gessi, purchè in banchi di un certo spessore e non frammisti ad argille, possono essere quasi sempre considerati a priori come aree carsiche, senza ulteriori indagini.

Nella maggior parte dei casi tali aree presenteranno caratteri morfologici di tipo carsico rilevabili anche dalla cartografia a grande scala (1:10.000 e 1:5.000) e ospiteranno grotte e sistemi carsici conosciuti, la cui ubicazione può essere ricavata dai catasti regionali delle grotte.

Gli affioramenti di dolomie e di calcari a basso tenore di carbonati (80% > $CaCO_3$ > 50%) oppure di calcari intercalati a marne, argilliti o selce, potranno essere considerati come aree carsiche in presenza di: cavità carsiche di un certo sviluppo, elevato coefficiente di infiltrazione (superiore al 30-40%), sorgenti di grossa portata, o comunque con portata percentualmente elevata rispetto alla risorsa idrica totale, sorgenti con caratteri idrodinamici che denotano una circolazione canalizzata.

In linea generale non sono da considerare carsiche quelle aree in cui i fenomeni carsici si limitano a rare e localizzate forme superficiali a piccola scala dovute alla azione delle acque di ruscelllamento: ad esempio nel caso di limitati affioramenti di blocchi, lenti o banchi di rocce carbonatiche o gessose compresi entro sequenze prevalentemente arenacee e/o argillose.

Non possono essere considerate carsiche aree con morfologie pseudocarsiche, come ad esempio grotte di origine non carsica: grotte laviche, grotte di deformazione gravitativa, etc.. Per queste aree, definibili più genericamente come aree di interesse speleologico, potrà nel caso essere istituito un elenco speciale a parte.

Nella delimitazione di un area carsica possono essere comprese anche zone di affioramento di rocce non carsificabili quando queste sono in qualche rapporto carsogenetico con l'area in esame, ad esempio quando si tratti di bacini di alimentazione allogenica, oppure quando si tratti di affioramenti di modesta estensione, o comunque in base ai criteri di necessità di seguire elementi fisiografici ben riconoscibili sul territorio.

Non esistono limiti dimensionali inferiore e superiore alla delimitazione di un area carsica. Si ritiene però di non dover eccedere in un senso o nell'altro delimitando aree carsiche di dimensioni troppo piccole, ad esempio inferiori a 0,1 km^2, o troppo estese, ad esempio superiori a qualche cerntinaio di km^2.

4. – STRUTTURA DEL CATASTO DELLE AREE CARSICHE D'ITALIA

Attualmente non esiste ancora un catasto delle aree carsiche d'Italia. Il progetto, ancora in fase di discussione, prevede in un primo momento la realizzazione di un archivio in cui siano raccolti i dati descrittivi principali delle aree carsiche.

La realizzazione di questo archivio pone già problemi non indifferenti per l'applicazione dei criteri di riconoscimento delle aree carsiche alle diverse situazioni geografiche italiane. Problemi derivano anche dal fatto che alcune regioni hanno già dei loro catasti delle aree carsiche basati su criteri non sempre conciliabili tra loro.

In primo luogo il catasto prevede la individuazione all'interno delle diverse regioni di singole unità orografiche delimitate da lineamenti geografici importanti, quali i fiumi principali, limiti di pianure alluvionali, linee di costa etc.. All'interno di queste unità orografiche vengono poi distinte le diverse aree carsiche secondo criteri prevalentemente morfologici e secondariamente idrologici, ma anche amministrativi e logistici (viabilità, accesso, etc.); è questa la fase più difficile legata ad un elevato grado di soggettività.

Risulta abbastanza chiaro che non esistono criteri validi per tutte le situazioni presenti sul nostro territorio, e che in più di un caso quello che dovrà guidarci nella delimitazione delle diverse aree carsiche deve essere soprattutto il buon senso legato ad una elevata conoscenze del territorio.

Delimitate le aree carsiche queste vengono numerate secondo un ordine progressivo di archiviazione ed identificate da un codice costituito dalla sigla di riferimento della unità orografica e da un numero o una lettera d'ordine.

I dati principali sono raccolti su di una scheda, di cui qui presentiamo una versione non definitiva (fig. 1), in

SOCIETÀ SPELEOLOGICA ITALIANA - CATASTO NAZIONALE DELLE AREE CARSICHE

sigla regione	numero progressivo
.....	.....

unità orografica
.....

denominazione
.....

sigla
.....

provincie interessate
.....

comuni interessati
.....
.....

cartografia IGMI - 1:25.000 serie 25
.....

coordinate geografiche - sistema E.D. 50	
limite N - .....° .....' ....."	limite S - .....° .....' ....."
limite W - .....° .....' ....."	limite E - .....° .....' ....."

altimetria
quota min. ..... quota max. ..... quota media .....

superficie km^2
.....

copertura rocce carsificabili	grado di sviluppo del carsismo	numero grotte conosciute
.....%	.....	.....

note:

Fig. 1. – Scheda di archiviazione del Catasto delle Aree Carsiche d'Italia (versione provvisoria).

– *Chard of the Register of the Italian Karst Areas (provisory version).*

caratteristiche geolitologiche
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caratteristiche morfologiche
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caratteristiche idrogeologiche
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caratteristiche speleologiche
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bibliografia principale:
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cui sono raccolti informazioni relative alla posizione geografica e alle caratteristiche fisiografiche, morfologiche, geologiche, idrogeologiche e speleologiche.

La scheda è accompagnata da una cartografia di scala adeguata che riporta i limiti dell'area carsica. Per la cartografia si prevede di utilizzare, quando possibile, le nuove carte IGMI in scala 1:50.000 o 1:25.000, o quelle tecniche regionali in scale 1:25.000 o 1:10.000, inquadrate nello stesso reticolo cartografico.

5. – CONCLUSIONI

Il Catasto delle Aree Carsiche d'Italia, in fase di realizzazione da parte della Società Speleologica Italiana, vuole essere un importante strumento di conoscenza del territorio.

Esso è strutturato in un catasto generale sintetico gestito dalla S.S.I., e in catasti regionali gestiti dalle singole federazioni spelologiche regionali o da altri organismi in collaborazione con gli organi amministrativi regionali.

Lo scopo ultimo è quello di mettere a disposizione dei vari organismi che operano sul territorio uno strumento di consultazione rapida che permetta di accedere ad una prima serie di informazioni e soprattutto di indirizzare indagini più di dettaglio relativamente ai fenomeni carsici presenti sul territorio.

Per il futuro si prevede di rendere il catasto delle aree carsiche un vero e proprio sistema informativo territoriale interattivo, in grado di fornire informazioni sulle caratteristiche ambientali delle aree carsiche.

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Censimento dei beni ambientali a carattere geologico nell'ambito delle aree protette della regione Liguria : primo contributo relativo al «parco naturale regionale di Bric Tana» - Comune di Millesimo (SV)

Survey of geo-environmental assets in the protected areas of Liguria region : first contribution concerning "Bric Tana regional natural park" in Millesimo (SV) - western Liguria

BURLANDO M. (*)

RIASSUNTO – Lo studio rappresenta il primo contributo di un programma di ricerca che intende realizzare il censimento e la schedatura dei beni geologici, geomorfologici, idrogeologici («geotopi») all'interno delle aree protette istituite in ambito regionale, in Liguria. Il «Parco naturale regionale di Bric Tana» costituisce un esempio di area protetta che deve la propria istituzione a prevalenti motivi di interesse geomorfologico – connessi alla presenza di manifestazioni carsiche superficiali e profonde, la cui origine e diffusione assumono un notevole valore scientifico – ma che offre anche altre singolarità ambientali con attributi scenici, didattici e ricreativi, tali da giustificare un dettagliato lavoro di schedatura e di valorizzazione degli aspetti fisici del paesaggio.

PAROLE CHIAVE: Patrimonio geologico, geotopi, aree protette, Liguria occidentale, Italia.

ABSTRACT – This paper represents the first contribution concerning a research plan to carry out the survey and the catalogue of geological, geomorphological, hydrogeological assets ("geotopes") in the protected areas system of Ligurian regional district. "Bric Tana regional natural park" is an example of protected area set up on account of prevailing geomorphological attributes; particularly, significant elements of epigeal and hypogeal karstic phenomena, with remarkable scientific value about distribution and morphogenetic mechanisms are signalized. "Bric Tana" park also shows further environmental peculiarities, containing scenic, didactic and pleasant attributes, such as to justify a detailed work of inventorying and emphasizing landforms, geologic-stratigraphic characteristics of rock formations, special pedogenetic conditions about surface deposits, erosion processes in different sites of the protected area.

KEY WORDS: Geological heritage, geotopes, protected areas, Western Liguria, Italy.

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1. – INTRODUZIONE

La conservazione del patrimonio geologico costituisce, da alcuni anni, un campo di applicazione di notevole interesse per numerosi studiosi delle Scienze della Terra ed universalmente è stato riconosciuto il ruolo fondamentale che la tutela e la valorizzazione dei caratteri fisici del territorio («geotopi») possono rappresentare sia in termini scientifici, sia in termini didattico-divulgativi (ANDERSEN *et alii*, 1990; STRASSER *et alii*, 1995; FABBRI & ZARLENGA, 1996; ZARLENGA, 1996).

Il presente lavoro costituisce un primo contributo relativo all'applicazione – in territorio ligure – dei criteri per la selezione ed il censimento dei beni geologici *l.s.* messi a punto di recente (AA.VV., 1991; WIMBLEDON *et alii*, 1995).

Proprio in Liguria questo approccio culturale trova una sua inequivocabile valenza, laddove particolari eventi tettonici e paleogeografici hanno forgiato un territorio complesso ed articolato, in cui aspri rilievi montani convivono con coste incantevoli. Diffusi, ancorchè talora poco conosciuti e valorizzati, punteggiano il territorio ligure siti di pregiato valore naturalistico-ambientale che rappresentano un patrimonio scientifico, culturale e didattico degno di essere studiato, classificato e salvaguardato.

Per tali motivazioni ed a seguito di importanti impulsi forniti dalle normative vigenti, è stata avvertita la necessità di predisporre un programma di ricerca finalizzato alla individuazione delle singolarità geologiche *l.s.* che caratterizzano la Liguria.

Tale programma ha preso avvio con una prima fase che prevede il censimento e la schedatura dei beni ambientali a carattere geologico (nella loro accezione più ampia) all'interno delle aree protette già istituite dalla Regione Liguria, al fine di contribuire ad una completa valorizzazione del territorio sottoposto a norme di tutela, di ordinare in un quadro più organico gli elementi di conoscenza già acquisiti sotto diverse forme e per altri scopi, di fornire, infine, strumenti di valutazione nell'ambito dei diversi livelli di programmazione e di pianificazione territoriale.

2. – IL PARCO NATURALE REGIONALE DI BRIC TANA

Nell'ambito del panorama delle aree protette liguri il presente studio ha individuato il Parco naturale regionale di Bric Tana (fig. 1) quale primo esempio di censimento dei beni ambientali a carattere geologico

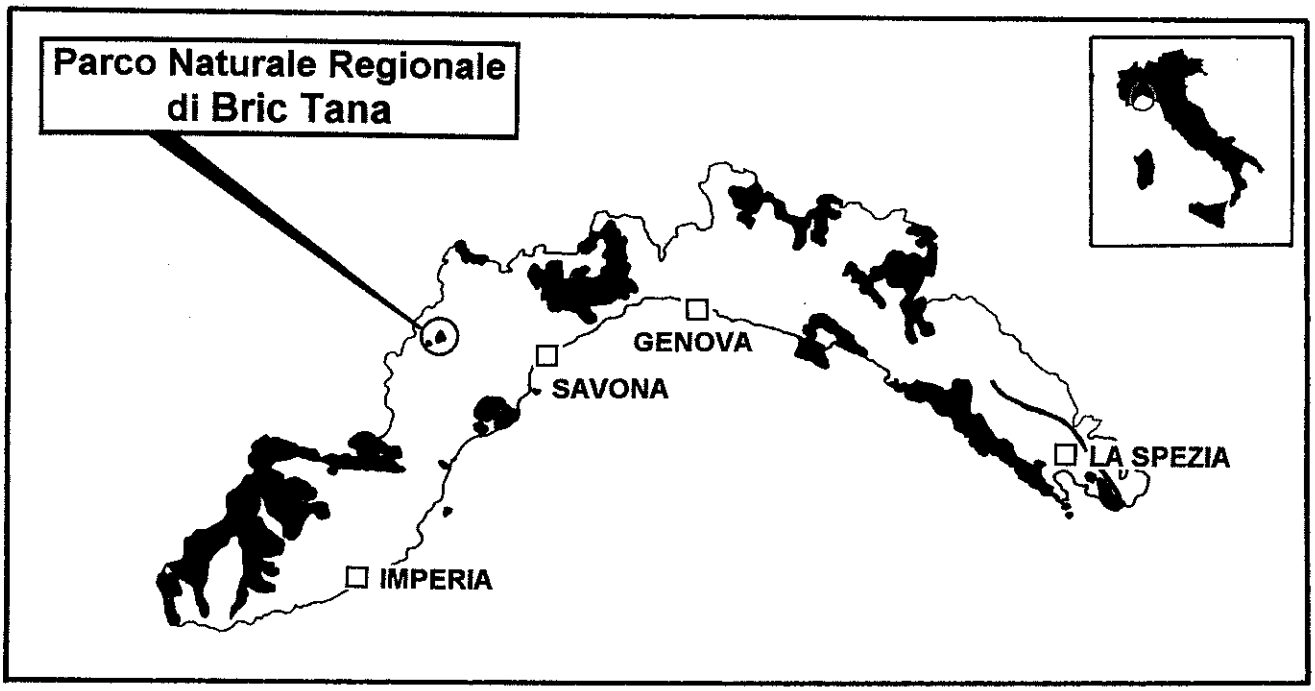

Fig. 1. – Distribuzione delle aree protette in Liguria (Italia Nord-occidentale), con ubicazione del «Parco Naturale Regionale di Bric Tana».

– Distribution of the protected areas in Liguria (North-western Italy), with location of the "Bric Tana Regional Natural Park".

l.s.; la scelta è stata giustificata dal fatto che tale area protetta deve la propria istituzione (L.R. n. 7 del 27.02.85) a prevalenti motivi di interesse geomorfologico, connessi alla presenza di manifestazioni carsiche superficiali e profonde, la cui origine e diffusione assumono un notevole valore scientifico.

L'area offre anche altre singolarità ambientali di notevole significato sia per quanto concerne gli elementi fisici del paesaggio (tra queste devono essere annoverate le caratteristiche geologico-stratigrafiche delle formazioni che costituiscono il substrato roccioso, particolari condizioni pedogenetiche rilevate nelle coltri di copertura, processi di erosione e di modellamento del territorio che contraddistinguono alcune porzioni dell'area protetta), sia per quanto concerne altri beni di valore naturalistico, quali attributi faunistici e vegetazionali, nonchè emergenze preistoriche ed archeologiche.

In base alle leggi regionali vigenti, la porzione di territorio in cui insiste il Parco di Bric Tana risulta tutelata – oltre che dalle normative sulle aree protette – dalla L.R. n. 22 del 16.04.84 (che regola il vincolo per scopi idrogeologici) e dalla L.R. n. 14 del 03.04.90 (che individua le aree di interesse carsico e speleologico).

2.1. – Inquadramento morfologico e lineamenti litologico-strutturali

L'area del parco può essere suddivisa in due ambiti principali, separati da una valle trasversale (Rio della Feia) incisa secondo una direttrice circa Est-Ovest:

- il settore settentrionale rappresenta un altopiano, lievemente ondulato sulla sommità e decisamente limitato a Nord e ad Ovest da un netto stacco morfologico costituito rispettivamente dal fondovalle del Rio San Sebastiano e da quello del Fiume Bormida di Millesimo
- il settore meridionale mostra, viceversa, forme maggiormente modellate con culmine rappresentato dal Bric della Feia (a quota 668 s.l.m.m.) e versanti più o meno acclivi, soprattutto lungo il limite occidentale, segnato dallo sviluppo del Fiume Bormida di Millesimo.

Ad un assetto morfologico relativamente semplificato fa riscontro una più articolata connotazione litologica, con presenza di diverse formazioni geologiche che costituiscono il substrato all'interno dei confini del parco (Servizio Geologico d'Italia, 1970; Società Geologica Italiana, 1991).

Nel settore Sud-occidentale è presente il «Dominio Brianzionese-Ligure» definito sia dai termini scistosi quarzo-sericitici e filladici del Tegumento Permo-Carbonifero (formazione degli *Scisti di Gorra* e *Formazione di Murialdo*), sia dalla copertura Meso-Cenozoica, rappresentata dalla formazione delle *Quarziti di Ponte di Nava* e dalle *Dolomie di S. Pietro dei Monti.*

Lungo il limite occidentale del parco affiorano, localmente, terreni appartenenti al Dominio Piemontese-Ligure e più specificatamente all'*Unità di Montenotte* che comprende – in questo comparto – metagabbri associati a filladi ed argilloscisti scuri con livelli calcarei.

Nei restanti settori prevalgono le formazioni oligoceniche relative al Bacino Terziario Piemontese che rappresentano depositi trasgressivi provenienti da Nord-Est, in discordanza rispetto ai terreni sottostanti. La serie è caratterizzata da sedimenti grossolani, conglomerati ed arenarie intercalate da bancate di calcari di scogliera, appartenenti alla *Formazione di Molare* e da prevalenti marne siltose, con livelli arenaceo-conglomeratici, che costituiscono la *Formazione di Rocchetta.*

3. - CENSIMENTO DEI BENI AMBIENTALI A CARATTERE GEOLOGICO

Come accennato in precedenza sono soprattutto le peculiarità geomorfologiche, connesse a particolari caratteristiche litologico-strutturali ed idrogeologiche *s.s.* di alcune specifiche formazioni, a rappresentare motivi di interesse nell'ambito del parco.

Scopo di questo primo contributo è stato quello di riordinare ed integrare le conoscenze e le segnalazioni bibliografiche con specifico riguardo ai beni ambientali di carattere geologico *l.s.*, nel tentativo di creare un inventario di tali beni, sottolineandone le valenze e proponendone una valorizzazione, anche a fini didattici e divulgativi, mediante la proposta di un itinerario a tematismo «geomorfologico».

3.1. – Valutazione e selezione dei beni ambientali a carattere geologico

Innanzitutto si è proceduto ad individuare le principali valenze dell'area; ne è scaturito un quadro estremamente ricco nell'ambito del quale sono stati riconosciuti attributi scientifici, riferiti sia alla tipologia dei processi morfogenetici, sia alla concentrazione ed alla quantità dei fenomeni rilevati.

In merito agli aspetti divulgativi sono stati valutati i concetti di vulnerabilità e di esemplarità didattica, nonchè quelli legati all'accessibilità a scopi educativi.

Per quanto concerne il grado di interesse (CARTON *et alii*, 1993) alcuni dei beni censiti all'interno del parco di Bric Tana assumono un'importanza a scala regionale, in considerazione di una comprovata peculiarità dei fenomeni rilevati; in altri casi è stata attribuita un'importanza a livello locale, legata alla specifica area di indagine.

In base ai criteri sopra elencati – all'interno dell'area protetta che si estende per una superficie di 170 ha – sono state individuate diverse tipologie di beni ambientali a carattere geologico *l.s.* (geotopi) e precisamente:

– forme carsiche superficiali e profonde:
  • doline di grandi e piccole dimensioni
  • inghiottitoi (attivi ed inattivi)
  • galleria sotterranea a sviluppo orizzontale
  • grotte ed antri di secondaria importanza

– forme di versante dovute a dilavamento ed effetti erosivi:
  • calanchi
  • pinnacoli

– forme fluviali:
  • forra torrentizia

– processi morfogenetici:
  • depositi grossolani (fino alle dimensioni di massi arrotondati, sub-sferici, reperiti in quota e lungo le incisioni vallive)
  • suoli relativi a fasi quaternarie di clima tropicale caldo-umido.

Specifico risalto, dal punto di vista scientifico, deve essere attribuito alle manifestazioni carsiche superficiali e profonde presenti all'interno dell'area del parco.

Tali manifestazioni sono dovute a particolari modalità morfogenetiche che hanno visto la creazione di cavità ipogee (nell'ambito di litotipi carsogeni quali, ad esempio, le intercalazioni di calcari di scogliera, presenti nella *Formazione di Molare* e limitate inferiormente dalla soglia impermeabile costituita dai metagabbri dell'*Unità di Montenotte*) associata a processi di pseudocarsismo, a carico della matrice carbonatica delle bancate arenaceo-conglomeratiche soprastanti, con formazione di morfologie epigee rappresentate da avvallamenti doliniformi di dimensioni più o meno significative. Ne è derivata, in taluni casi, l'origine di «valli cieche» che catturano le acque di scorrimento superficiale e le drenano in profondità lungo percorsi estremamente complessi.

3.2. – SCHEDATURA DEI BENI CENSITI

Il censimento vero e proprio ha comportato la predisposizione di apposite schede, per la cui struttura sono stati presi a riferimento i criteri illustrati in lavori di recente pubblicazione (REGIONE MARCHE, 1991; CASTO & ZARLENGA, 1992, 1996; ARNOLDUS-HUYZENDVELD *et alii*, 1995).

Tali schede hanno tenuto conto dei numerosi dati e segnalazioni bibliografiche desunte da studi e ricerche già effettuate nell'area stessa (CORTEMIGLIA *et alii*, 1968; REGIONE LIGURIA, 1985; REGIONE LIGURIA - COMUNE DI MILLESIMO, 1995; BELLINI & FILIPPI, 1996) riordinati ed integrati da specifici rilevamenti di verifica sul terreno.

L'obbligo di sintetizzare in uno spazio necessariamente ridotto le risultanze di questo studio preliminare sul censimento dei geotopi all'interno del «Parco naturale regionale di Bric Tana» non consente di allegare le schede redatte, per le quali si rimanda ad un successivo contributo; in tal senso, tuttavia, si ritiene doveroso fornire, di seguito, un sintetico elenco dei beni censiti (fig. 2).

– Scheda n. 1: Comprende un ampio avvallamento doliniforme impostato nella Formazione di Molare, con inghiottitoio esplorabile («Grotta de l'Orpe» - galleria di circa 150 m a sviluppo sub-orizzontale). La grotta è stata più volte oggetto di indagini speleologiche. Nelle immediate vicinanze della grotta è stato individuato un sito archeologico di notevole importanza a livello regionale. Nei settori circostanti si segnalano ulteriori doline, di dimensioni inferiori rispetto alla principale, con inghiottitoi obliterati per la presenza di depositi colluviali e terreno vegetale.

– Scheda n. 2: Insieme di doline di discrete dimensioni in loc. Le Vigne. Inghiottitoi occultati da depositi colluviali, in taluni casi adibiti a coltivazioni agricole (fig. 3).

– Scheda n. 3: Processi erosivi tipo «calanchi» a carico delle marne della «Formazione di Rocchetta» in loc. La Colla (esternamente al limite orientale dell'area protetta).

– Scheda n. 4: Insieme di avvallamenti doliniformi, con inghiottitoi occultati da terreno vegetale, in loc. Case Rocchini di Sopra. Punto panoramico.

– Scheda n. 5: Terrazzo morfologico ed esempi di processi pedogenetici nell'ambito delle diverse formazioni geologiche («Formazione di Molare» e metagabbri dell'Unità di Montenotte) in loc. Case Rocchini di Sotto.

– Scheda n. 6: Insieme di tre doline di grandi dimensioni, in loc. Casa Tana, con presenza di in-

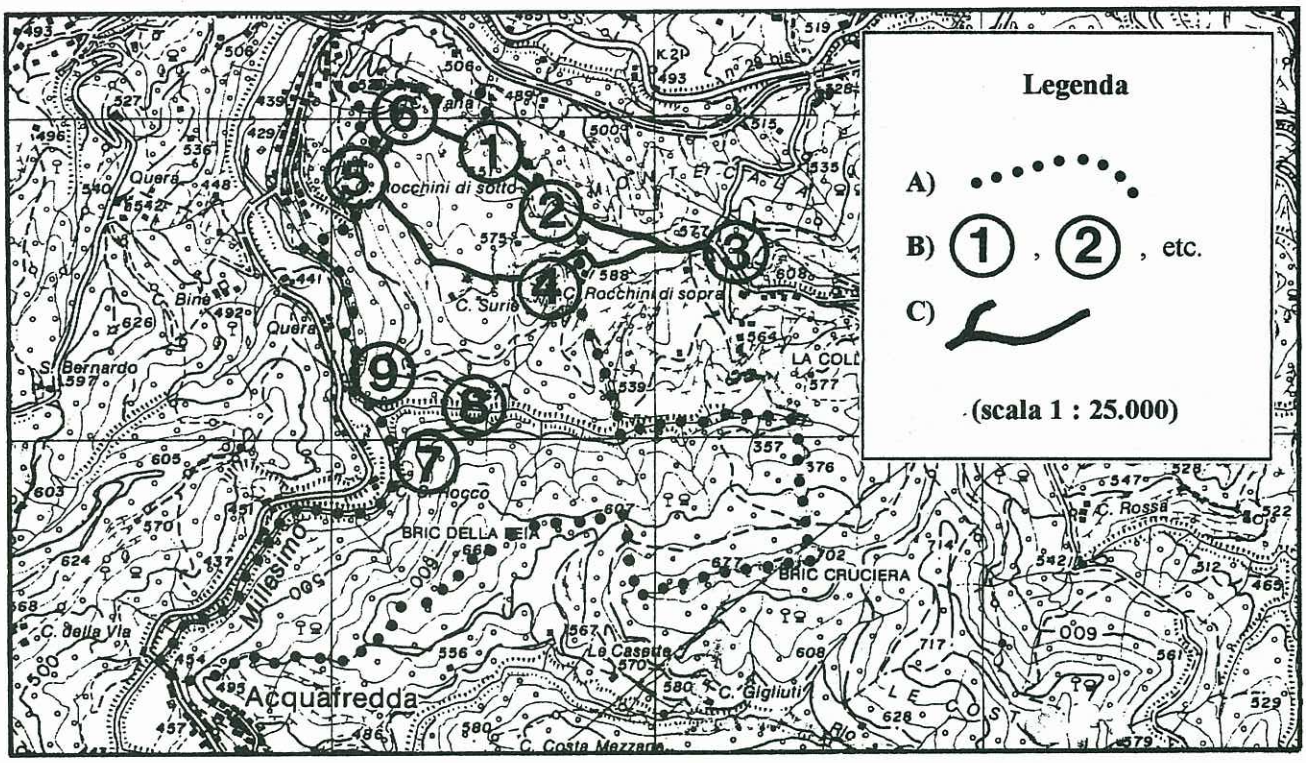

Fig. 2. – Planimetria con i confini del «Parco Regionale Naturale di Bric Tana» e posizionamento dei siti di interesse geologico. Legenda: A) confini dell'area protetta; B) sito di interesse geologico con numerazione relativa alla scheda predisposta; C) itinerario a tematismo «geomorfologico».

– Map concerning boundaries of the "Bric Tana Regional Natural Park" and location of the selected geological sites. Legend: A) boundaries of the protected area; B) selected geological site with numbering of the pertinent schedule; C) thematic "geomorphological" trail.

Fig. 3. – Vista dall'alto dell'ampia dolina in loc. Le Vigne (scheda n. 2).

– View of the large sink in loc. Le Vigne (schedule n. 2).

ghiottitoi attivi (seppure non esplorabili) ed inghiottitoi inattivi (occultati da depositi colluviali e terreno vegetale).

– Scheda n. 7: Pinnacoli scolpiti nella formazione delle «Dolomie di S. Pietro dei Monti», in sponda destra del Fiume Bormida di Millesimo, direttamente a Sud della confluenza con il Rio della Feia (fig. 4).

– Scheda n. 8: Forra torrentizia nell'alveo del Rio della Feia, inciso nella formazione delle «Dolomie di S.Pietro dei Monti».

– Scheda n. 9: Insieme di quattro grotte («Antro sul Bormida», «Grotta Rifugio», «Tana Superiore al Rifugio» e «Grotta della Fornace») nell'ambito della formazione delle «Dolomie di S. Pietro dei Monti», in sponda destra del Fiume Bormida di Millesimo, direttamente a Nord della confluenza con il Rio della Feia.

Fig. 4. – Scenografico esempio di «pinnacoli» scolpiti nella formazione delle «Dolomie di S. Pietro dei Monti», in sponda destra del Fiume Bormida di Millesimo (scheda n. 7).

– Scenic example of "pinnacles" carved in "Dolomie di S. Pietro dei Monti" formation, by right side of the Bormida di Millesimo River (schedule n. 7).

3.2.1 – Proposta di itinerario a tematismo geomorfologico

In base alla distribuzione ed alla specificità dei beni censiti, nonchè all'accessibilità dei luoghi, il presente contributo intende formulare una proposta per la creazione di un itinerario a tematismo «geomorfologico», strutturato in modo tale da fornire, oltre alla semplice fruizione turistico-paesaggistica, una specifica valenza didattica, e far sì che il visitatore possa godere delle spettacolari forme della natura ricevendo, contestualmente, nozioni scientifiche inerenti i vari aspetti del territorio.

Tale itinerario (fig. 2) riprende in parte i percorsi escursionistici già esistenti, ma prevede la dotazione di pannelli informativi – adeguatamente posizionati lungo il tracciato, in corrispondenza dei beni censiti – ove vengano illustrati, anche con rappresentazioni grafiche, i processi geomorfologici in atto in un particolare settore o la sequenza stratigrafica del luogo o la sezione della grotta esplorabile o indicazioni in merito alle condizioni di vulnerabilità dei siti, ecc.

L'attrezzatura di un itinerario a tematismo «geomorfologico» potrà rappresentare un'ulteriore iniziativa – a carattere scientifico e didattico-divulgativo – a corredo delle numerose attività di promozione e valorizzazione del parco regionale.

4. – CONCLUSIONI

Il programma di censimento, avviato in questa prima fase limitatamente alle aree già tutelate da vincoli di salvaguardia, verrà successivamente esteso a tutto il territorio ligure, allo scopo di pervenire alla formulazione di originali proposte di conservazione e di valorizzazione del patrimonio geologico (nella sua accezione più ampia) e di stimolare l'eventuale adozione di appropriati provvedimenti legislativi a cura dell'Amministrazione Regionale.

Si auspica, infine, l'informatizzazione dei dati censiti, mediante l'utilizzo di un Sistema Informativo Territoriale (GIS) opportunamente organizzato ed in grado di interagire con altri sistemi regionali e nazionali, per la creazione di una «banca dati sui geotopi» che potrebbe rappresentare uno strumento di fondamentale importanza per quanto concerne la pianificazione territoriale e la gestione del patrimonio ambientale.

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Geoconservation in Germany - 1996
Geoconservazione in Germania - 1996

GRUBE A. (*)

ABSTRACT – In the past years – since the conference in Digne – some important steps have been taken to strengthen geoconservation in Germany. Two larger working groups have been set up. A working group inside the Geological Surveys, which are officially concerned with geoconservation in Germany, has established a standard working guide, which summarises the existing inventories in all German states and includes evaluation procedures and nomenclature regulations (see article in this volume). A private working group was set up to popularise geoconservation issues and bring together all interested geoscientists and regional geoconservation groups in the country. This group which holds meetings once in a year has become a section of the German Geological Society recently. The existing inventories of geotopes in Germany comprise more than 12.000 sites of which only a part is protected in some manner. Many older inventories will be revised during the next years and be implementated into computer based GIS systems. The Rammelsberg, a lead-zinc-iron ore mine has been protected as a side product within the ancient town Goslar (Harz mountains). The oil-shale pit of Messel with a subtropical to tropical Eocene flora and fauna has been declared as UNESCO World Heritage Site in 1995.

KEY WORDS: Geoconservation, Germany, state of the art.

RIASSUNTO – Negli anni passati – a partire dal convegno di Digne – sono stati compiuti alcuni passi importanti per rafforzare la geoconservazione in Germania. Sono stati costituiti due importanti gruppi di lavoro, un primo gruppo all'interno dei «Geological Surveys», cui compete ufficialmente la geoconservazione in Germania, ha stabilito un manuale di lavoro standard, che riassume gli inventari esistenti in tutti gli stati tedeschi ed include procedure di valutazione e regole di nomenclatura (vedi la referenza in questo articolo). Un secondo gruppo privato è stato creato per diffondere le pubblicazioni sulla geoconservazione, riunire tutti i geologi interessati e i gruppi di geoconservazione regionali nel paese. Questo gruppo, che si riunisce una volta all'anno, è divenuto recentemente una sezione della Società Geologica Tedesca. Gli inventari esistenti dei geotopi in Germania comprendono più di 12.000 siti dei quali solo una parte è in qualche modo protetta. Molti inventari più vecchi saranno rivisti nei prossimi anni e saranno implementati in sistemi GIS. Il Rammelsberg, una miniera di ferro-zinco-piombo è stata protetta nell'ambito dell'antica città di Goslar (montagne di Harz). La cava di scisti bituminosi di Messel, con una flora ed una fauna dell'Eocene da subtropicale a tropicale, è stata dichiarata nel 1995 Sito dell'Eredità Mondiale dell'UNESCO.

PAROLE CHIAVE: Geoconservazione, Germania, stato dell'arte.

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1. – INTRODUCTION

The most frequent term for Geoconservation used in Germany is "Geotop-Protection". Geotops are defined as "valuable sites which comprise characteristic and sensitive elements, structures, forms or active processes, which are accentuated by their scarcity, singularity, diversity, special earthhistorical importance, form, or beauty. They can be of natural and artificial character. Geotopes are vulnerable, are of special importance for science, education and history, and have to be protected from destruction or negative alteration". This definition is oriented on simple and legal already defined terms, it has thus not yet been incorporated into German nature conservation laws. The expression Geological Nature Monument ("Geologisches Naturdenkmal") is also frequently used; in the Geological Surveys the term "GeoSchOb" (geoscientifically valuable sites) has for a long time been used.

Possibly the earliest attempts to protect geotopes reach back to 17th century (GESELLSCHAFT ZUR FÖRDERUNG DES NATIONALPARKS HARZ, 1992). The first nature reserve was established in 1836 (Drachenfels, "dragonrock" close to the Rhine), a little later the late variscian granite Totenstein ("deadstone") in Sachsen (1844) and the Teufelsmauer ("devilswall"), a hogback north of the Harz-Mountains (1852) were protected. The first attempts to establish larger protection areas reach back nearly a hundred years, when the poet Hermann Löns (1866-1914) worked actively for the establishment of a large nature protection area in the Harz mountains. If we look back to the first systematic approaches of geoconservation in Germany, we have to name the member of the Preussian Parliament WETEKAMP, who held a speech on the necessity of integrating geography and geology into nature conservation, and the botanist H. CONWENTZ. The first Act on the Conservation of Nature in Germany was passed in 1935. For further detailed historical information and negative examples (of which there is quite a number) see GRUBE (1994a, b) and WIEDENBEIN (1994).

2. – LEGISLATIVE ASPECTS AND PROTECTION CATEGORIES

In general the legislative possibilities for an efficient protection of earth science sites are given. Responsible for a protection is the Federal Act on Nature Conservation, which provides a juridical frame for the states ("Länder"), which develop more detailed laws of their own. Other laws in effect are the Monument Protection Law in the states, which can be applied e.g. for active quarries and fossils. No federal Monument Protection Law exists. Furthermore a number of other environmental resources and landscape planning laws affect in part geotopes. The soil protection law that is under preparation does only partly include the possibility of protection of soil profiles.

In some geoscientists opinion the Monument Protection Law causes problems, because sites are usually protected under the nature conservancy act, whereas fossils can, in most of the states, become protected under the Monument Protection Laws. In this way sites and fossils are handled in a different way. The situation of the protection of fossils differ somewhat in the single states. While Baden-Württemberg and Nordrhein-Westfalen played a pioneer role in the protection of fossils and have efficient laws, fossils in Bavaria are as good as unprotected. The loss of unique fossils resulting from these gaps in the legal statutes have been described by WILD (1988). For further information on paleontolocical issues see NIEMEYER (1989) and WILD (1993). On the other hand, some sites are today practically inaccessible, because the nature protection law puts the protection of the site to the highest value. Examples have been stated, where not even samples for micropaleontological work could be taken from the protected site (RIEGRAF, 1991). Obviously the difference between the protection of plants and animals and geological objects is not quite clear to many people concerned with nature conservation. Recently the "Working Group for Palaeontologi-cal Soil Monument Protection" inside the German Palaeontological Society has produced a draft about the protection of fossils and fossil sites to be included into the statutes of the society (NIEMEYER, 1996).

For the above mentioned reasons the desire to include a special passage on geoconservation in the Act on Nature Conservation is growing. Proposals for such a law have been published by ALBERTS & BURGHARDT (1986), detailed concepts for a generalised decree for the protection of geotopes have been worked out by LOOK *et alii* (1993). Here possibilities of admittance for "bona fide" scientific purposes to protected sites could be determined in general.

The range of possibilities to incorporate geoconservation in planning procedures is large. Of special importance are Environmental Impact Assessments ("UVP") which include valuable sites (both biological and landscape/geology) in the case of new construction works. Efforts have been undertaken from the geological side to implement geoconservation in it.

Geotopes have also been integrated into Regional Plans and Planning Frame Plans, which are the basis for planning procedure on a regional scale.

In the former German Democratic Republic the legislative frame was given by the States Culture Law from 1970. The responsibility for nature conservation was situated with the representatives of the municipality, the counsellor of the Republic ("Räte der Republik") and the commissioners of the districts ("Bezirksnaturschutzbeauftragte"). In general geoscientists were not well presented in these institutions. Therefore initiatives from geoscientists were taken: persons from the above mentioned institutions, universities, museums, and the VEB's (nationalised enterprises) carried out the evaluation, mapping, description and finally the application for protection (HÄNDEL, 1974; WAGENBRETH, 1974; PRESCHER, 1975).

Today there is no special protection category which especially applies to geoscientific features, though a specific "Geological Nature Monument" existed in the former GDR. Geotopes can directly be protected in National parks (altogether 2% of the area of Germany), Nature Reserves (2.3%), Nature Monuments (<<1%) and Protected Landscape Components (25%), they can be protected as "side products" in Landscape Protection Areas (<<1%) and Nature Parks (16%). The latter are not a protection category but a planning instrument. Geotopes can, of course, be protected as "side products" in some other categories also, e.g. in Biosphere Reserves and as Soil Monuments. The responsibility for Nationalparks and Nature Parks lie on a national level; Natures Reserves and Landscape Protection Areas are dealt with on a state level, nature monuments are in the responsibility of the municipalities.

3. – INSTITUTIONS CONCERNED WITH GEOCONSERVATION

The responsibility for the registration, mapping and evaluation of sites generally lies in the hands of the Geological Surveys (GLAs) with its federal head, the Federal Bureau for Geoscience and Resources (BGR). The GLAs are in some states affiliated to the Environmental authorities with which in some cases the registration is carried out. One of the reasons for the inadequate representation of valuable protected sites in Germany is that the GLAs do not have a deciding influence on the protection of sites, but act as consultants only. The GLAs are trying to become responsible authorities for geoconservation though.

An official geoconservation working group is active in the GLAs since 1992. It is concerned with the development of juridical terms, the standardisation of evaluation techniques, mapping procedures and the digital registration of important geotopes in Germany (see AD-HOC-AG GEOTOPSCHUTZ in this volume).

Private initiatives enabled two meetings for geoconservation in the 80ies: one in Laufen/Salzach (former West-Germany) organised by HAGEDORN & SCHUMACHER (1982) and the other in Bautzen (former GDR; GESELLSCHAFT FÜR GEOLOGISCHF WISSENSCHAFTEN, 1985). Official bodies were taking part in these meetings also.

In 1992 the "Workinggroup on Geotop-Protection" was founded as a result of the Digne-meeting (WIEDENBEIN & GRUBE [Eds.], 1992). The task of the group which shows an interdisciplinary composition and which is working on a national level is to promote geoconservation in general, to act as a forum for new developments and enhance or carry out scientific projects. The working group has working sessions once a year with different topics (ÖBO MITWITZ, 1993; QUASTEN [Ed.], 1993; VERBANDSGEMEINDE GEROLSTEIN [Ed.], in Print; KREUTZER & SCHÖNLAUB [Eds.], 1995; FISCHER & LEMPERTZ [Eds.], in Print), with between 50 and 100 participants. One of the most important achievements of the group is having spread and popularised the term "Geotop" and to have promoted geoconservation in general. The working group has become an official section of the German Geological Society recently. Besides that group a small number of regional groups are working in single states, some of them for a long time (e.g. in SACHSEN, FREYER & HÄNDEL 1996). A new working group has been formed in Thüringen recently (BRUST, 1996).

During a conference on geoconservation in Mitwitz and Cologne in 1993 ProGEO was founded as an association (WIEDENBEIN [Ed.], 1993).

The activities of private persons in geoconservation are not yet very strong. Nevertheless a number of private groups is also taking care of single geotopes. The Nature Conservation Law requires a supervising group ("Betreuungsvereine"), which is normally build up from different groups (native groups, bird protection groups, etc.) and which will take care of the site, develop onsite interpretation, etc.

4. – JUSTIFICATION, STATE OF REGISTRATION AND PROTECTION

The arguments stressed for the protection of geotopes are the same as in other countries. Scientific,

educational, economical (e.g. tourism) and historical reasons are the most frequently named. Criteria applied in different approaches in the course of evaluation of geotopes are the following: number of different disciplines (e.g. palaeontology, geomorphology), frequency, state of preservation, aesthetic value, relevance for science and education and accessibility of a site. The criteria set of the Geological Surveys very much accentuated geotopes as part of the natural landscape system. Furthermore earthhistorical reasons, the state of a site in comparison to the ideal form of a site (e.g. of a geomorphologic form), existence of geotopes sets and subjective additional values have been used in some approaches (fig. 1).

The evaluation mainly started at the beginning of the 70ies. Lower Saxony was the first state to start in 1969, others countries followed (LÜTTIG, 1971; GERMAN, 1974; BECKER-PLATEN, 1982; SCHÖTTLE, 1984). The first systematic evaluation of geotopes in the German Democratic Republic were based on a more homogeneous concept (WAGENBRETH, 1970) and started at the beginning of the 60ies.

The evaluation and mapping is carried out by the Geological Surveys, in some cases the Environmental Authorities and private persons (e.g. from universities or museums) have added to the inventories. Geotope inventories are also part of the mapping of biotopes, but generally this approach is not very successful, because geoscientific knowledge is lacking there and

Fig. 1. – Wingertsberg in the Eifel mountains: Laacher See volcanism (last glaciation maximum) with surge, flow- and ash-fallout deposits as well as bombs of some meters in diameter (BOOGARD & SCHMINCKE, 1985). Protected as geoconservation site in the present form (Photo: A. GRUBE, 1993).

– Wingertsberg nelle montagne Eifel: vulcanismo di Laacher See (ultima grande glaciazione) con surge, flussi, depositi di ricaduta e bombe di alcuni metri di diametro (BOOGARD & SCHMINCKE, 1985). Protetto come sito da geoconservazione nella forma attuale (foto di A. GRUBE, 1993).

the number of geotopes looked for are very small (e.g. springs, cattle holes).

Nowadays Inventories exist for all states, but these are heterogeneous in completeness, concept and quality. The differences are the result of the varying geology in the different regions, varying engagement of geologists in the regions, different intensities of threat towards geotopes and other reasons. Probably the most advanced inventory (both numeric and maps) exists in Lower Saxony. Bavaria was leading in the development of an evaluation system as well as a computer based informationbase used by the Geological Surveys. The geotopes here are implemented into a GIS system for soil protection (LAGALLY *et alii*, 1993). Existing maps show the geotopes in the different states on varied scales (e.g. 1:200.000 - 1:500.000).

Nevertheless a large number of geotopes have been taken into consideration. After having finished the registration in all areas in all more than 14.000 geotopes will be registered or described in Germany (AD-HOC-AG GEOTOPSCHUTZ, 1996). This number will increase if detailled studies will have been carried out on all federal states. Only a part of these geotopes is protected in some manner. This generally positive picture has to be corrected, because some of the categories do not give severe protection. E.g. in Landscape Protection Areas the construction of houses and roads, in some cases even aggregate extraction is possible. In general many sites are under threat, e.g. through the planned construction of new landfills, buildings etc. Examples are the important sites of Nördlinger Ries and sites in Holzmaden. Recent publications illustrate the growing knowledge on geotopes in Germany on a regional scale (FREYER & HÄNDEL, 1996; HÄNDEL, 1991; KARPE, 1994; LAGALLY *et al.*, 1993; ÖBO MITWITZ, 1993).

In 1992 the "Working Group on Geotop-protection" responded to the inquiry from the WH Task Force for the UNESCO list at the Digne-meeting. The list, which was presented at the "1st International Symposium on the Protection of our Geological Heritage" in Digne, at that time contained only four German sites: Bundenbach, Messel, Holzmaden and Solnhofen. The above mentioned working group set up a list of 16 sites, to which two were added in 1993 during a Geological Heritage Meeting in Cologne. The list is now under review in the Geological Surveys and the Federal Bureau for Geoscience and Resources (BGR). This work takes a lot of effort, because a large number of sites has to be evaluated and compared. Recently the historical town of Goslar (Harz mountains) has been protected as UNESCO World Heritage Site. As part of this protection zone the Rammelsberg, a lead-zinc-iron ore mine which has been mined for a long time, has been protected. As second geoscientific site the oilshale pit of Messel with a subtropical to tropical Eocene flora and fauna has been declared to be a UNESCO World Heritage Site in 1995.

Some issues (e.g. geomorphology and pedology) have generally been neglected in geotope protection in the past (SOYEZ, 1982; HIEKEL, 1987). More emphasis will hopefully be put on these topics in the future. Research projects on geomorphological geotopes have been financed by the Federal Environmental Ministry (BAUER & SEIDEL, 1992). First attempts to include important soil profiles into conservation strategies have been set up and some maps have been compiled (e.g. ZALF & INSTITUT FÜR BODENKUNDE, 1993). Of interest for geoconservation are also National Parks (GRUBE, 1994b), because these give severe protection, comprise geotope ensembles and in part also show active geological processes. Some of the National Parks are under threat by intensive tourism, construction works, military use etc., fortunately this does usually not influence geoscientific sites.

Valuable for geoconservation, though used touristically and altered in their natural style, are also showcaves of which some thousand exist [pers. comm. W. ROSENDAHL, GERMAN ASSOC. FOR CAVE AND KARST RESEARCHERS). Of relevance are also old mines that are used as touristical objects, of which more than sixty exist in Germany (pers. comm. F.W. WIEDENBEIN, Erlangen). BRUST (1996) describes the difficulties that occur within the finalised geoconservation maps in the single states because caves and karst forms are not adequately represented. This is after this Author not only is a result of lacking knowledge from the official bodies but also because of the attitude of cavers, who do not want a cave to become known to the public and missing publications or documentations of sites.

New concepts of geoconservation, geological publicity work and touristical use of geotopes are oriented at the form of Geoparks, of which a number exists in the Eiffel mountains (e.g. ESCHGHI, 1995). In general there is a large number of possible Geological Parks, e.g. the Eifel-region and the Nördlinger Ries, which are of special attractivity to the public and can in this way have a positive influence on the popularisation of geoconservation.

5. – FUTURE PROSPECTS

The Geological Surveys have to become more involved in the actual protection procedures of geo-

conservation sites, if possible they should be responsible for it. The registration and evaluation of sites has to be carried out on a heterogeneous level all over Germany. This implies that many older inventories will have to be revised according to numeric evaluation systems. The basis for this work, a set of criteria to get the geotopes into a priority list is carried out by the Geological Surveys. The evaluation of sites will have to be done on the basis of the implementation into computerbased systems, which will be the coming medium for landscape planning. The geoconservation section inside the German Geological Society should play a manifold and encouraging role in geoconservation and will also work on an European and international level, e.g. together with ProGEO. Despite the fact that a large number of geotopes have already been protected this does not veil that a large part of the existing valuable sites is still unprotected - the need to save these for future generations is still an immense task.

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An inventory of geomorphological geotopes in the canton of Fribourg (Switzerland).

Un inventario dei geotopi geomorfologici nel Cantone di Friburgo (Svizzera)

GRANDGIRARD V. (*)

ABSTRACT - This article constitutes a plea for the management of the geomorphological heritage. The Author presents the reflections and the research carried out in the context of an inventory of geomorphological geotopes in the Canton of Fribourg and outlines the various steps of the process. Particular attention is paid to the stages of categorization and evaluation of the geomorphological objects, as they raise numerous methodological problems.

KEY WORDS: Geotopes, geomorphology, inventory, Fribourg (Switzerland).

RIASSUNTO - Questo articolo è un argomento a sostegno della gestione dell'eredità geomorfologica. L'Autore presenta le riflessioni e le ricerche portate avanti nel contesto di un inventario dei geotopi geomorfologici nel Cantone di Friburgo e delinea i vari passaggi del processo. Particolare attenzione è rivolta agli stadi della categorizzazione e della valutazione degli elementi geomorfologici, poichè essi sollevano numerosi problemi metodologici.

PAROLE CHIAVE: Geotopi, geomorfologia, inventario, Friburgo (Svizzera)

1. – INTRODUCTION

The term "geotopes" denotes "parts of the geosphere having particular importance for the comprehension of the history of the Earth" (GRANDGIRARD, 1995; 1996). Geotopes are the memory of the Earth's past and the key for the comprehension of its present and future state. They are an essential element of the natural heritage. Any form of development should respect the value and the singularity of this heritage.

Due to the absence of a constraining legal basis (STÜRM, 1994a; 1994b), several regions and cantons have been pioneers in establishing geotope inventories in Switzerland. In particular, the district of Gorgier (NE) (RIEDER, 1995), the region of Val de Réchy-Sasseneire (VS) (TENTHOREY & GERBER, 1993), the county of Werdenberg (SG) (SCHLEGEL, 1987), and the cantons of Aargau (BAUDEPARTEMENT DES KANTONS AARAU, 1982), Zürich (KYBURZ *et alii*, 1983; KYBURZ, 1983), Zug (VOGEL, 1986), Graubünden (WEIDMANN, 1994) and Luzern (VOGEL, 1995) should be mentioned. In addition, the efforts of the working group for the protection of geotopes in Switzerland (STRASSER *et alii*, 1995), which is currently preparing an inventory of geotopes on a national scale, should also be noted.

In this context, the inventory of the geomorphological geotopes in the Canton of Fribourg is interesting for several reasons. Firstly, due to its location between the molasse basin and the Alps (fig. 1), the canton of Fribourg (1670 km^2) is characterized by a very diverse natural environment (GRANDGIRARD & MONBARON, 1995). Secondly, this inventory is established within the scope of the development of a sector plan of landscapes and sites (TEAM, 1993; 1995). Lastly, this inventory is based on a totally new and original methodological process.

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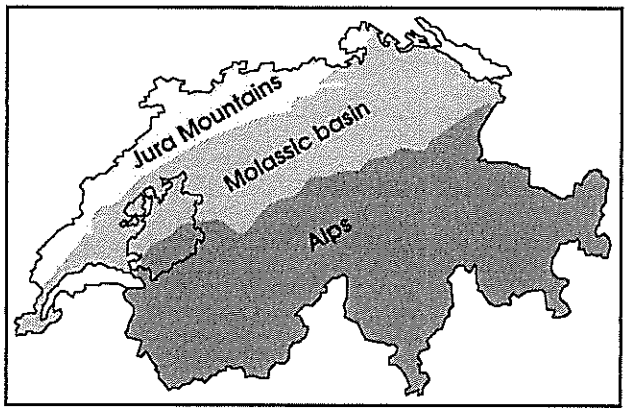

Fig. 1. – Location of the canton of Fribourg in Switzerland.

– Ubicazione del Cantone di Friburgo in Svizzera.

2. – THE AIMS

The inventory of geomorphological geotopes allows the demonstration of the geomorphological wealth of the canton of Fribourg. It is presented in the form of a catalogue of landforms that can be observed in the cantons. Each type of landform is illustrated by one or several outstanding examples.

This inventory has to serve three purposes:

- to provide detailed information about the nature and the genesis of the cantons relief and consequently to this description, to promote the understanding of cantonal landscapes;
- to demonstrate the significance of geomorphology in the study of the natural environment and the necessity of considering this fundamental dimension in the management of the natural heritage;
- to produce a list of geomorphological objects of great value, deserving particular attention. This inventory can be used as a reference for the study and the evaluation of the cantons relief.

It is important to note that objects which are not listed are not valueless and that, for any action having an effect on the relief and/or its dynamics, the geomorphological component must be taken into consideration.

3. – THE PROCESS

The inventory of the geomorphological geotopes constitutes basic information for users who often do not have any particular knowledge in the field of Earth sciences. To become a reference, this inventory must deliver convincing and understandable results. It must therefore be based on a clearly defined process as well as on solid scientific data.

The proposed process for the realization of this inventory can be broken into five successive stages:

- categorization of geomorphological objects;
- inventory of the geomorphological objects;
- evaluation of the geomorphological objects;
- selection of the geomorphological geotopes;
- characterization of the geomorphological geotopes.

The following focuses on the presentation of this process. Particular attention is paid to the categorization and evaluation of the geomorphological objects, as they raise interesting methodological problems.

3.1. – THE CATEGORIZATION OF GEOMORPHOLOGICAL OBJECTS

The expression "geomorphological objects" refers to variable entities such as: limited landforms, wide sites and even landscapes representative of a particular relief.

A categorization of these objects is necessary to systematize and to facilitate the collection of data as well as to improve the intelligibility of the results. The mode of categorization applied must be based on established scientific reasoning whilst remaining simple in conception and application.

The proposed mode of categorization is based on a classical method of classification used in contemporary geomorphology that arranges landforms according to the geomorphological process recognized as responsible for their genesis. This approach has been completed by the use of systemic notions.

These preliminary theoretical reflexions led us to classify the geomorphological objects in four categories of increasing complexity (fig. 2): isolated landforms, sets of landforms, complexes of landforms and geomorphological systems.

- Isolated landforms and the sets of landforms result from the activity of one dominating process and they present only one type of landform. An alluvial cone, a terminal moraine or a polje are isolated landforms.
- An alignment of dolines or a field of drumlins are sets of landforms.
- Complexes of landforms result from the activity of a single dominating process and they present many types of landforms. For example a karstic area where many solution landforms can be observed (like karren, dolines, uvalas, ponors, poljes and caves) forms a karstic complex.

- Geomorphological systems are important concentrations of landforms of different types and result from synchronous and successive processes interacting on the same area.

This mode of categorization presents many advantages. Its main interest lies in the fact that it allows the construction of an inventory covering the complete range of geomorphological objects, from the simplest to the most complex. Moreover, it allows the demonstration of the "including-included" relationship between these objects. Finally, this mode of categorization may be used at different scales.

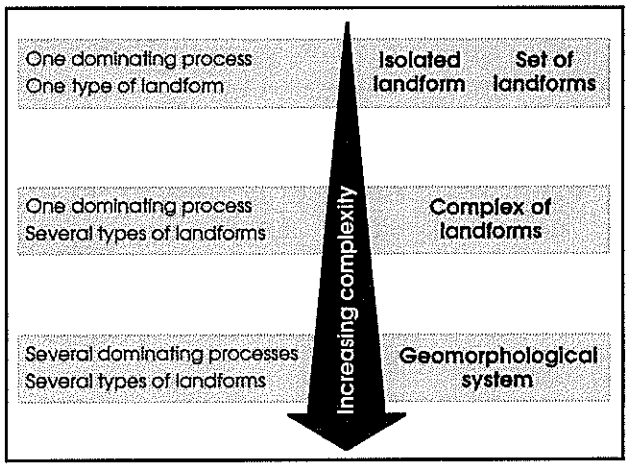

Fig. 2. – The four categories of geomorphological objects.

– Le quattro categorie di oggetti geomorfologici.

3.2. – The inventory of the geomorphological objects

The study of topographical maps at different scales (from 1:10.000 to 1:100.000), of geological maps, of the available Earth-sciences literature, of aerial photographs, as well as field work allow the listing of the isolated landforms and sets of landforms by landform type and by geomorphological process. Complexes of landforms and the geomorphological systems are defined in a further step.

Because of the multiplicity, the complexity and the evolution of the phenomena considered, such an inventory cannot aspire to be exhaustive.

3.3. – The evaluation of the geomorphological objects

The evaluation of geomorphological objects is a delicate operation which can be influenced by the subjectivity of the observer. In order to be as objective as possible, this evaluation must follow a strict procedure.

Two fundamental requirements have conditioned the choice of the evaluation criteria: they must allow the assessment of the scientific value of the objects studied, from the geomorphological point of view (their ecological, scenic, cultural, etc. value are not considered), and they must be suitable for the evaluation of all the geomorphological objects.

Two types of criteria are distinguished, according to their significance in the evaluation process: the factors and the indicators (fig. 3).

The factors are the fundamental criteria. The value of a geomorphological object corresponds to the combination of the results obtained in the evaluation of each factor.

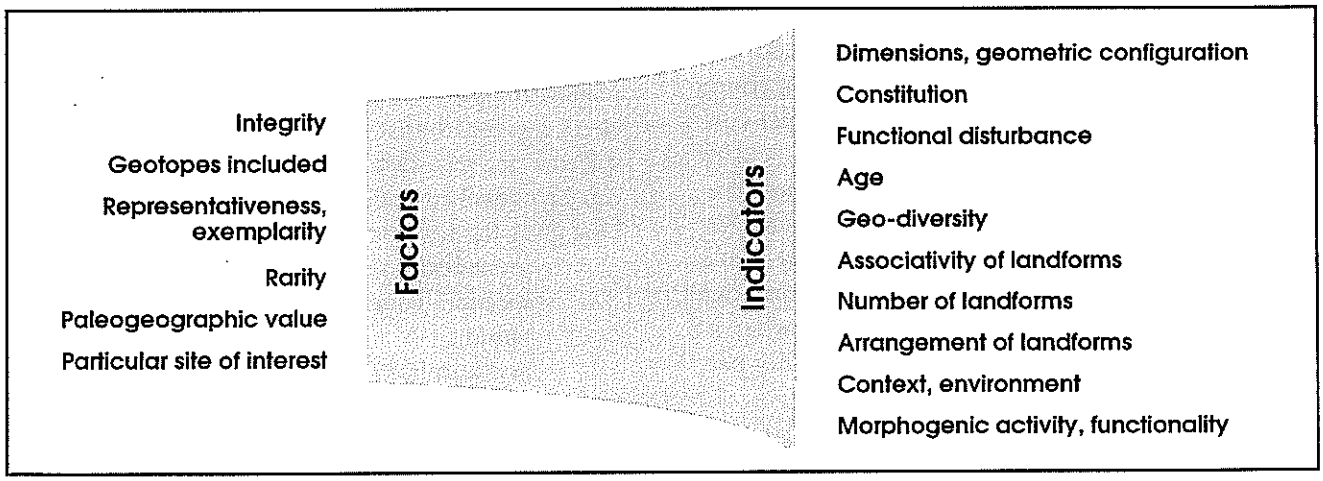

Fig. 3. – The criteria considered to evaluate the geomorphological objects.

– I criteri utilizzati per la valutazione degli oggetti geomorfologici.

The indicators are secondary criteria, necessary for the evaluation of the factors. An indicator may be useful for the evaluation of several factors.

Only the factors, which are the main criteria, are described below.

- Integrity: corresponds to the degree of preservation of the original characteristics (geometric configuration, constitution, functionality, etc.) of the geomorphological object considered. Integrity is mainly graded relative to the degree of human intervention.
- Geotopes included: geomorphological objects encompassing geotopes are graded in a similar manner to biotopes containing rare or endangered species.
- Representativeness, exemplarity: this factor corresponds to the didactic value and "readability" of the observed phenomena (landforms and processes). The representativeness is graded differently for each category of geomorphological object. Isolated landforms and sets of landforms are evaluated through comparison with other geomorphological objects of the same type, or with the ideal type of the landform or set of landforms in question. Complexes of landforms are judged according to how well they reveal past or current activity of a generative process. Geomorphological systems are valued depending on their capacity to illustrate the characteristics of a "geomorphological region". The latter is conditioned by the prevailing lithological, stuctural and climatic conditions, considered to be approximately uniform. The most representative geomorphological systems thus concentrate in a limited area almost all of the phenomena likely to be found there.
- Rarity: this factor is assessed in relation to an area of reference – the canton of Fribourg in the present case. Rarity is evaluated concerning both the type of geomorphological object considered (e.g. rarity of alluvial fans, of field of drumlins, of karstic complexes, of geomorphological systems of the molasse basin) and its particular characters. It is interesting to note that a geomorphological object can be very rare, due to certain exceptional characteristics, whereas the type of object to which it belongs is not particularly rare.
- Palaeogeographic value: some geomorphological objects constitute irreplaceable "witnesses" of the history of the Earth. Their palaeogeographic value depends on the information they may convey through their geometric configuration, their constitution, their age, the distribution of the landforms, their environment and location, their activity, etc.
- Particular site of interest: a geomorphological object presents an increased scientific value if it has been or is the subject of research. Its value as a research site is linked to the knowledge already accumulated or likely to be furnished by current or future research.

3.4. – The selection of geomorphological geotopes

Two conditions govern the selection of geomorphological geotopes:

- only the objects of great geomorphological value are selected;
- the geotopes listed, considered as a whole, must be representative of the diversity of relief features that can be observed within the canton.

The factor "rarity" must be given particular attention during the selection process because of this second condition: the value of scarce geotope type is mainly determined by the rarity factor, whereas that of common geotopes depends on other factors. Most of the rarest objects, of which only a few examples exist, should be selected, whereas only a small proportion of common objects should be chosen.

3.5. – The characterization of geomorphological geotopes

The inventory of geomorphological geotopes in the canton of Fribourg represents a source of information for planners and for other users such as teachers, regional tourist offices, hikers, etc. The geotopes selected are recorded in a structured database which can be consulted easily. For every geotope, this database gives the following information:

- identification and designation;
- location (coordinates, altitude and map delimitation);
- geomorphological description (context and characteristics);
- morphogenesis (formation, evolution, age and current activity);
- results of the evaluation;
- information sources.

Other information may complete this database, such as threats, management prescriptions, visibility and scenic value, ecological value, economical interest, accessibility and leisure value, cultural and historical significance, etc.

4. – THE RESULTS

The inventory of geomorphological geotopes in the canton of Fribourg (Switzerland) encompasses more than 300 geotopes that represent almost 40 types of landforms and illustrate the activity of five major geomorphological processes (fluvial, glacial, karstic, limnopaludal and slope processes).

5. – CONCLUSIONS

The method proposed above is used in the context of the inventory of the geomorphological geotopes in the canton of Fribourg. It is very efficient, due to the simplicity of its application and its flexibility.

This method could be applied with equal success to other research areas and to other uses (e.g. environmental impact assessment). It is not linked to a particular working scale and lends itself to numerous adaptations according to needs and constraints (e.g. time, financial and technical).

The derivation of an inventory of geomorphological geotopes masks important progress in the management of the natural heritage in the canton of Fribourg. The management of geomorphological heritage nevertheless remains in an embryonic state in this canton, as elsewhere in Switzerland. This domain constitutes a wide field of investigation and of activity for geomorphologists. They should:

- continue and intensify basic research, encourage research on little-known regions or phenomena, and interdisciplinary research (on the natural environment, on the landscape, etc.);
- develop applied research, in collaboration with nature protection and landscape planning authorities:
  - by contributing towards the development of efficient management instruments at all planning scales (local, regional, national and international), allowing decision-makers to integrate the geomorphological component;
  - byriate planning measures;
- make proposals to integrate the protection of geotopes into current legislation;
- make efforts towards greater popularisation and information, in order to increase public awareness of the geomorphological aspects of the landscape and of the value of the geomorphological heritage.

Incorporating the geomorphological component systematically into nature and landscape management serves the interests of both the natural environment and the population. It is important that geomorphologists mobilize in order to promote this cause, which is undoubtedly dear to them.

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The Italian caves register
Il catasto delle grotte d'Italia

FERRARI G. (*) & PICCINI L. (*)

ABSTRACT - Since the beginning of modern speleology, cavers have collected a great number of documents about caves. These documents especially concern the localisation of the entrance and the geological, hydrological, morphological and biological features of caves. All the documents are currently conserved by caving associations and so they are not of easy consultation. To make them available for the community, official registers of caves have been established. Cave registers represent important, but often unknown, geographic inventories. The collected data can be useful for many environmental researches and in particular for geomorphological and hydrogeological researches in karst areas. Indeed many caves have a considerable naturalistic and environmental value and sometime they have the necessary qualities to be defined and protected as a geotope.
In Italy, the first national register of caves was established in 1929 by the Italian Institute of Speleology, but in the sixties it progressively failed because of the difficulties in keeping it up-to-date. The new project of the Italian Caves Register, carried out by the Italian Speleological Society (S.S.I.), concerns a computerised database where the main data of all the Italian caves are registered, while more detailed information can be obtained from regional inventories. The national register will be easily accessible; read-only software for Windows is now developed and it will soon be available on a BBS station and through the Internet.

KEY WORDS - Speleology, cave inventories, karst research

RIASSUNTO - Sin dalla nascita della moderna speleologia, gli speleologi hanno raccolto una grande mole di documenti riguardanti le grotte esplorate. Questi documenti riguardano in particolare la localizzazione degli ingressi, le dimensioni, e le caratteristiche geologiche, idrologiche, morfologiche e biologiche delle grotte. Tutti questi documenti sono conservati in archivi gestiti dalle singole associazioni speleologiche, ma sono in genere difficilmente accessibili al pubblico. Per rendere disponibile alla comunità la massa di dati raccolti sono stati creati dei catasti ufficiali.
I catasti delle grotte rappresentano degli importanti archivi geografici e i molti dati raccolti possono essere di grande utilità per ricerche di tipo ambientale e in particolare per studi a carattere geomorfologico e idrogeologico sulle aree carsiche. Molte grotte hanno inoltre un elevato pregio naturalistico e ambientale e talvolta posseggono le caratteristiche per essere definite e protette come geotopi.
Il primo catasto nazionale delle grotte d'Italia fu istituito dall'Istituto Italiano di Speleologia, nel 1929, ma in breve la sua importanza decrebbe per la difficoltà di mantenerlo aggiornato a causa del crescente numero di grotte esplorate. Oggi, il nuovo progetto del Catasto delle Grotte d'Italia, portato avanti dalla Società Speleologica Italiana (S.S.I.), prevede un database informatico dove sono raccolti i dati principali di tutte le grotte italiane. I dati registrati sono: numero di registro (sigla della regione e numero progressivo), nome di identificazione, localizzazione (comune e area carsica), le dimensioni della grotta e gli autori dei rilievi topografici. Il catasto nazionale non contiene i dati riguardanti le coordinate geografiche degli ingressi, le caratteristiche geologiche, idrologiche e morfologiche, e il rilievo topografico; tali documenti sono reperibili presso i catasti regionali competenti.
Il catasto nazionale, vuole diventare soprattutto un archivio di facile accesso contenente i dati principali di tutte le grotte. A tal fine è stato realizzato un programma di consultazione per Windows, del quale si può richiedere una copia su dischetto, e che presto sarà accessibile presso una stazione BBS e tramite Internet.

PAROLE CHIAVE - Speleologia, catasti delle grotte, ricerche carsiche

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1. – INTRODUCTION

Cave registers probably were one of the first geographical and naturalistic inventories. In Italy, the first registers of caves were established at the beginning of this century. The most important, in Italy and probably in the world, was the register of Venezia Giulia, that in 1920 contained more than 2000 caves; part of this register was published in the volume "Duemila Grotte" of L. V. BERTARELLI & E. BOEGAN (1926), printed by Touring Club Italiano.

In 1929 the Italian Speleological Institute, with its office in Postumia (Slovenia), founded the Register of Italian Caves, with the aim of collecting all the data about caves of Italy; this national office followed the structure of the Venezia Giulia Register and it continued its activity till the 2nd World War, collecting data and surveys of almost 7000 caves (ANELLI , 1941).

During the following years the national register was not able to keep itself up-to-date because of the great number of explored caves; so in the seventies regional registers, normally managed by the federations of regional caving associations, were established. In the eighties, many of the regional registers were transferred into computerised databases. At the present time almost all the Italian administrative regions have cave registers available on personal computers, this circumstance permits to develop a new national register easily up-dating and easily accessible.

2. – STRUCTURE OF THE ITALIAN CAVES REGISTER

The Italian Caves Register is a simplified inventory which contains the main data of all the explored caves in Italy. The guidelines define a cave as a natural cavity, of any origin, accessible to Man, and with a length more than 5 metres. Every cave is marked with the abbreviation for the administrative region followed by a

SOCIETA' SPELEOLOGICA ITALIANA
CATASTO DELLE GROTTE D'ITALIA

T / 1000 / MS

ABISSO OLIVIFER
sinonimi:

Comune: MASSA
Area Carsica: FRIGIDO

Dislivello negativo: m 1215 positivo: m 0 totale: m 1215
Sviluppo spaziale: m 7200 planimetrico: m 4500 Estensione: m 950

Rilievo: G. S. Fiorentino Anno: 1989-1994

note: la cavità presenta due ingressi catastati con due numeri diversi, l'altro ingresso, situato a quota inferiore è catastato con il numero T/MS.1267

Fig. 1. – Example of the database card of the Italian Caves Register.
– Esempio di scheda del Catasto delle Grotte d'Italia.

sequential accession number. Every region has its own numeration, which reflects the order of registration.

A simple card-index (fig. 1) contains the main data of identification, of approximate geographical location, and of dimension. The following are the selected data for the national register; they represent a common 'core' of all the regional registers (CONCI, 1956, BAGLIANI *et al.*, 1990, FALLANI & PICCINI, 1989).

Regione (abbreviation of administrative region) - indicating the administrative district (region in Italy) and consequently the regional register.

Numero (number of register) - the sequential number of registration in the card-index.

Provincia (abbreviation of administrative province) - initials of the administrative province in which the cave is located.

Nome (name) - the official and first name of the cave; local names or toponymy are usually preferred.

Sinonimi (other names) - different names of the same cave; the official name is the first to be published, but some caves are known with names different from the official one.

Comune (administrative municipality) - name of the municipality in which the entrance of the cave is located.

Quota (elevation a.s.l.) - elevation of the entrance above sea level; the datum is taken at the lower rim of the entrance.

Dislivello negativo, positivo, totale (negative, positive and total height) - the first and the second are the differences of altitude between the entrance and the lower and upper points effectively reached in the cave; the total height is the sum of the two.

Sviluppo spaziale, planimetrico, estensione (spatial and planar development, extension) - the spatial development is the real development of cave, practically the sum of all the possible paths in the cave; the planar development is the total planar length of all the branches; the extension is the maximum planar distance between two different extremities of the cave. (The measure of development depends upon the accuracy of survey and the method of computation, for these reasons development is always an approximate value; the development of the greatest cave are usually rounded to the nearest ten metres).

Rilievo (survey authors) - gives the names of the Authors (speleological associations, or people) who did the topographic surveys.

Data (date) - date when the survey was made.

The geographic co-ordinates and cartographic references are available only from regional registers, together with topographic surveys and all the documents regarding geological, hydrological and morphological information.

The national register must be easily accessible, this implies that it cannot contain all data because there is the need to protect the work of cavers from illegal publication and to reduce the length of database; regional registers collect all the documents concerning caves, but in order to protect the caves of considerable naturalistic value not all data can be freely consulted.

3. – THE IMPORTANCE OF THE CAVE REGISTER

Cave registers collect data about physical and biological features of all the caves explored in a region, so they can be considered important inventories of environmental elements. The collected data can be useful for many researches, particularly for geomorphological and hydrogeological researches in karst areas, where caves represent the most important morphologic features.

Furthermore, many caves have considerable naturalistic and environmental value and sometime they have the necessary qualities to be defined and protected as a geotope.

There are many scientific interests and reasons for protection and for conservation of caves; the most important are:

Geology - Caves are natural 'drillings' that allow information to be directly gathered about underground geological settings. The exposure of clean surfaces of no weathered rock often permits a stratigraphic and tectonic resolution not possible in the outcrops on the earth surface. In particular, there can be found the effects of neotectonics; this kind of research can be very important for palaeo-seismic studies.

Hydrology - Karst aquifers are one of the most important resources of drinkable water in the world. In karst areas water underground drainage is controlled by karst conduit network, developed from the infiltration area to the springs; caves are the accessible portion of this network. The study of cave hydrogeology is very important to understand the dynamic of underground flow in karst aquifers, to delimit the feed area of a karst spring and to estimate its pollution vulnerability.

TAB. 1 – The present situation of the regional registers of caves in Italy. 'Great' caves are those deeper than 300 m or longer than 3000 m.

– *L'attuale situazione dei catasti regionali delle grotte in Italia. Si considerano 'grandi' grotte quelle con profondità superiore a 300 m o sviluppo superiore a 3000 m.*

REGION	Number of caves	Number of 'great' caves
Piemonte - Valle d'Aosta	~ 2000	32
Lombardia	~ 3000	26
Veneto	5561	20
Trentino - Alto Adige	1503	7
Friuli Venezia Giulia	5533	41
Liguria	1360	0
Emilia - Romagna	750	1
Rep. di San Marino	50	0
Toscana	1310	41
Marche	500	4
Umbria	859	3
Lazio	~ 1200	9
Abruzzo	~ 500	0
Molise	~ 100	2
Campania	1250	8
Basilicata	210	0
Puglia	1700	1
Calabria	~ 300	1
Sardegna	~ 2000	13
Sicilia	~ 700	4
TOTAL ...	**~ 30350**	**303**

Ecology and global change - Caves are strictly connected with the surface environment and any change of it is reflected in caves as morphogenetic or deposition events. Thanks to the high preservation potential of caves (the reader must think of the exceptional state of conservation of palaeontological and prehistoric remains in caves) elements may be found for a very detailed reconstruction of past environmental changes. Caves can be exceptional environmental data recorders, therefore they are important for the study of the human effects on the world's ecosystem.

Palaeontology and prehistory - Caves have always been refuges or traps for animals and Man, therefore palaeontological and prehistoric remains in caves are abundant. A great part of our knowledge about animals evolution and prehistory of Man is due to remains discovered in caves.

Biology - The study of cave life is now one of the most important fields of research of evolutionary biology. In fact, caves are biological 'islands' where relict species can survive and where some species have found a refuge with low biological competition.

Tourism - Caves can be an important tourist attraction. Easily accessible caves can offer to nature lovers fascinating excursions. In few carefully estimated cases, particularly attractive caves can be equipped for mass-tourism, with a positive effect on local economy.

Taking account of all these arguments caves often can be considered very important geotopes, in particular, the large karst complex where the geo-ecological history of the last millions years is preserved.

4. – THE COMPUTERISED REGISTER

National and regional registers are central repository of paper-cards and cave maps. Data may be consulted at the office or they may be transferred by mail. Interested people have to contact directly the office to get documents about caves.

The personal computer technology makes possible a different approach to data distribution: copies of a read-only programme of the national register database can be requested, but only the regional co-ordinator, who is in possession of the copy of the read-write programme, can correct data and add new cave-cards.

A first attempt to realise a national computerised cave register was made in 1985 (FERRARI & FORTI, 1995), but it failed because of the two following reasons:

1) several regional co-ordinators didn't possess the necessary computer knowledge to deal with an unfriendly programme;

2) some regional registers developed an own programme and database different from the national one.

The present approach is to collect only the main data from the computerised regional registers, as already explained in the section 2 of this paper. Several data conversions of the regional registers have allowed to realise a database with the data of almost all the Italian regions. A MS-Windows read-only programme is under test, and any potential users can ask for a floppy-disk copy of the read-only programme and of the national database. The next step will be to design and develop an user-friendly backward-compatible regional programme (read-only and read-write versions).

Network technologies allow a further method for the distribution of data. An official Italian cave register BBS (Bulletin Board System) has been developed by the Veneto Cave Register. It will be completely operative in 1996. Users with a PC and a modem can connect to the phone number 0444/56947. They can browse all the data otherwise available on floppy-disk.

The national register will not be distributed through the Internet. Only a cave atlas, with the largest caves of Italy (about 200 charts), will be available on World Wide Web pages. Each chart reports the essential data about a single cave, with a brief description, contact points, bibliographic references and a digital copy of the survey. The next step will be the development of Web pages for the major karst areas.

5. – CONCLUSIONS

Detailed knowledge of caves and cave systems is an important step towards the understanding of karst areas and related resources. The Italian Caves Register, managed by the Italian Speleological Society (S.S.I.), is the most important instrument to get available such knowledge. Many caves have so important natural features to be considered geotopes, and caves should be considered part of the natural heritage of a region.

A better collaboration between caving associations, ecologist associations and scientific researchers is desirable to study and to protect caves and karst areas.

Caving associations (S.S.I., Regional Caving Federations) are involved in a big voluntary effort to keep the registers up-to-date and to exploit the possibilities of new technologies of data distribution.

At the present, there is few co-operation between caving associations and public authorities, because no national law and only some regional laws have been approved concerning cave registers.

A carefully worded national law should establish:

1) the national cave register as an official institution structured on regional basis; it should be managed by caving associations in collaboration with the public authorities;

2) a set of information services about caves and karst areas, based on the network technologies;

3) a well working co-operation between public authorities and caving organisations concerning projects of research, exploration, protection, training, tourist development, safety and rescue.

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Conservation of geosites in Finland - a case study from Helsinki

La conservazione dei geotopi in Finlandia - un caso tipico da Helsinki

KANANOJA T. (*)

ABSTRACT – The conservation of geosites in Finland is mostly regulated by the Nature Conservation Act and the Soil Act. The Nature Conservation Act prescribes the establishing of nature reserves, while the Soil Act controls the excavation and exploitation of soil and the use of bedrock as dimensional stone and aggregate. The supreme authority in environmental protection in Finland is the Ministry of the Environment. Bodies subject to Ministry of Environment ensure that the environmental laws are obeyed.
Two extremely old potholes were found in Helsinki in 1993. These potholes are considerably older than other dated potholes in Finland, having formed over 50.000 years, possibly over 100.000 years ago. Therefore, they pre-date the last glaciation and are thus unique in Finland and, most probably, in all Scandinavia. The Helsinki environmental committee has placed the potholes under a protection order as a natural monument and an internationally valuable geosite has been saved.

KEY WORDS: Finland, geoconservation, pothole

RIASSUNTO – La conservazione dei geotopi in Finlandia è regolata prevalentemente dalla Legge per la Conservazione della Natura e dalla Legge sul Suolo. La Legge per la Conservazione della Natura prescrive la costituzione di riserve naturali, mentre la Legge sul Suolo controlla lo scavo e lo sfruttamento del terreno e l'utilizzo delle formazioni rocciose secondo le caratteristiche delle pietre e degli aggregati. La più alta autorità nella protezione ambientale in Finlandia è il Ministro per l'Ambiente. Gli organismi soggetti al Ministro per l'Ambiente assicurano il rispetto delle leggi ambientali.
Due marmitte antichissime sono state scoperte ad Helsinki nel 1993. Queste marmitte sono considerevolmente più vecchie delle altre marmitte finlandesi già datate, essendosi formate più di 50.000 anni fa, forse più di 100.000. Esse perciò risalgono a prima della glaciazione e sono così uniche in Finlandia e, più probabilmente, in tutta la Scandinavia. Il comitato ambientale di Helsinki ha posto le marmitte sotto protezione come monumento naturale ed un sito di valore internazionale è stato così salvato.

PAROLE CHIAVE: Finlandia, geoconservazione, marmitta

1. – LEGISLATIVE BASE

The conservation of geosites in Finland is mostly regulated by two acts, namely the Nature Conservation Act and the Soil Act. The Nature Conservation Act came into force in 1923. Together with the other Nordic countries, Finland was one of the first countries to make nature conservation a statutory duty in those days (HAAPANEN, 1988; PALOKANGAS *et alii*, 1993).

The Nature Conservation Act prescribes the establishing of nature reserves both on state and private lands.

- Small sites can be protected as natural monuments if the site is of scientific or natural significance (HAAPANEN, 1988). Most protected small geosites are designated specially as natural monuments. These are mostly erratics, potholes and caves, with erratics being clearly predominant. Besides these we also have many other small geosites of international and national value, which should be protected very soon. First, however, such sites must be identified and registered (SUOMINEN & KANANOJA,

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Fig. 1. – The overall view of the potholes after emptying and fencing them. At the foreground, left side, is the smaller pothole; larger pothole is in the background. The ice has flown from north to south (from left to right in the photo).
(Photo by H. HIRVAS)

– Visione completa delle marmitte di erosione dopo il loro svuotamento e ricinzione. In primo piano, a sinistra, si nota la più piccola; la marmitta più grande è sullo sfondo. Il ghiacciaio ha defluito da nord verso sud (da sinistra a destra nell'immagine).
Fotografia di H. HIRVAS)

1994). Accordingly, in recent years several geosite inventory projects have been set up to help in establishing new geosites for conservation.

- For larger features such as eskers and mires there are separate protection programmes (HAAPANEN, 1988). In recent years Finland's eskers have been greatly damaged by gravel extraction. The esker protection programme ensures that representative parts of our eskers will be preserved for their landscape, scientific and recreational value. The peatland protection programme is also necessary, because the majority of our mires are no longer in their natural state (HEIKKILÄ, 1994).

There are also numerous geological sites within nature reserves and national parks (KONTTURI, 1991), but by no means all have been listed, because the protected areas were not established for geological reasons.

The Soil Act, which came into force as late as 1982, controls the excavation and exploitation of soil and the use of bedrock for stone and aggregate. The Act forbids the destruction of unique natural occurrences, for example valuable surficial deposits and bedrock sites. However, no permit is needed for extraction for household purposes (PALONKANGS *et alii*, 1993). Such extraction is defined so broadly that a valuable geological site, for example an esker, can be destroyed without the authorities having power to prevent it (ALAPASSI, 1994).

Besides these above mentioned cases the conservation of geosites is also incorporated into the Building Act, the Mining Act and the Antiques Act. The Building Act controls the extraction and excavation of natural recources in areas covered by urban planning or prohibitory measures as stated in the Act. Under the Mining Act everyone has the right to search for ores on land without the permission of the landowner. However, the Act forbids exploration in protected areas. Under the Antique Act historical quarries and mines can be protected (PALONKANGS *et alii*, 1993).

The supreme authority in environmental protection in Finland is the Ministry of the Environment, which was established in 1983. For geosite conservation the land-use department is the most important department at the Ministry of the Environment. It deals with urban planning and other land-use planning, land policy, sustainable use of nature resources, nature conservation, landscape management and recreational use of nature (PALONKANGS *et alii*, 1993). The Finnish Environment Agency (FEA) was established in 1995 to continue the activities of the National Board of Waters and Environment. The FEA is the research institute of the Ministry of the Environment and institute concentrates on R&D underpinning sustainable development. Protection of the ground is also among the activities of the FEA. Since 1991 decision making concerning protection of small sites as natural monuments has been transferred from the provincial government to municipal environmental protection committees at local authority level. This simplifies the conservation of small geosites as natural monuments.

2. – TWO INTERNATIONALLY VALUABLE POTHOLES FOUND IN HELSINKI

Two potholes found in 1993 at Pihlajamäki, Helsinki, during the construction of a pedestrian and cycle route serve as an example. Potholes are formed by the action of glacial meltwater flowing at the base of ice sheet, where stones rolled and eroaded circular depression in the bedrock (ALEXANDER, 1932). All previously known potholes in Finland date from the latest deglaciation, with ages ranging from 10.000 to 12.000 years. The two potholes at Pihlajamäki are considerably older, having formed over 50.000 years, possibly over 100.000 years, ago (HIRVAS, 1995). After the melting of the ice sheet there was nonglacial phase,

whose precise duration is not known. During the last glaciation the ice sheet covered the area again and deposited till over the potholes. The Pihlajamäki potholes thus predate the last glaciation since they are overlain and partly filled by till deposited by the most recent ice sheet, and were formed by the action of meltwater at the end of the previous glaciation. The potholes have been formed over approximately 100 years. They are thus unique in Finland and, most probably, in all Scandinavia. The larger pothole is in fact the largest so far recorded from Finland. It is oval in shape, with a maximum diameter of 6.90 m, and a depth of 8.45 m. The diameter of the smaller pothole is 1.60 m and its depth is 3.20 m (HIRVAS, 1995) (fig. 1).

Figure 2 shows a cross section through the larger of the Pihlajamäki potholes. A brief description of the pothole sediments is given below. (A) 1.9 billion years old migmatitic bedrock in which the pothole have formed. (B) represents till formed during the last glaciation, and covers a thin layer of sand (C) that has probably been deposited by melt water during ice retreat. Beneath this sand was a layer of stones and boulders (D), which probably represents material dislodged from the roof of an ice tunnel. Beneath this was a layer of silt and sand (E) deposited by a subglacial river, with the basal unit (F) consisting of 4.5 m of gravel and including grinding stones (HIRVAS, 1995).

Following a submission by the Helsinki Environment Center and based on the decentralisation, authorised by the 1991 decision, the Helsinki environmental committee placed the potholes under a protection order as natural monuments in March 1995, and the pedestrian and cycle route had to be re-located (HIRVAS, 1995). The whole process took only about two years between discovering the potholes and having them protected. Thus, an internationally valuable geosite, which, for a moment actually faced blasting, was saved, thanks to the fast action on the part of the discoverer. There are still a few drillholes visible, which were once filled by dynamite. After construction was stopped the site was jointly taken care of by the City of Helsinki and Geological Survey of Finland; the City emptying and reclamation of the potholes, and the Geological Survey provided scientific assistance by making analyses and writing the text for the information boards (HIRVAS, 1996 pers. com). In addition to its great scientific value, the geosite is also useful for teaching, as there are several schools, and even a university, nearby.

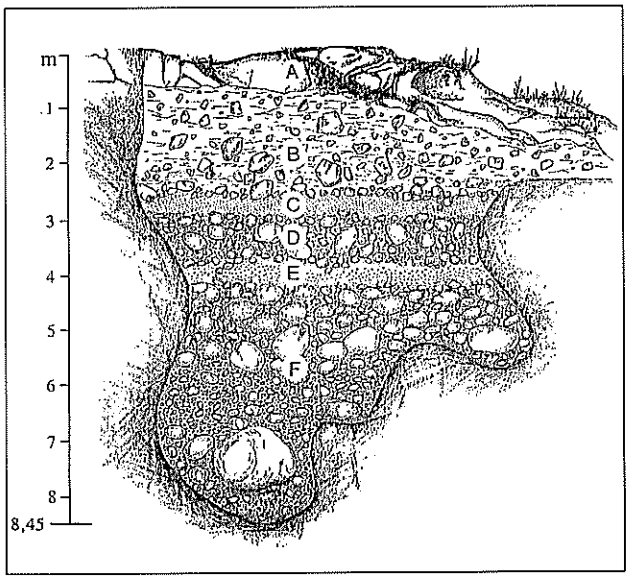

Fig. 2. – Cross section of the larger pothole and the strata found from the pothole. For detailed information see text. (Figure from HIRVAS 1995)

– Sezione verticale della marmitta maggiore, con gli strati rinvenuti nella stessa. Per informazoni dettagliate si consulti il testo. (Disegno da HIRVAS 1995)

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Siti geologici di rilevante interesse in Abruzzo
Important geosites in Abruzzi

MASSOLI-NOVELLI R. (*), AGOSTINI S. (**), BURRI E. (*) & PETITTA M. (*)

RIASSUNTO - L'Abruzzo possiede numerosi e importanti siti geologici, soprattutto riguardanti i cicli sedimentario, tettonico, geomorfologico.
Un buon numero di questi siti geologici sono già compresi in aree protette, di cui l'Abruzzo, definito regione «verde» d'Europa, risulta particolarmente dotato. Molti altri siti sono però fuori di parchi o riserve naturali e conseguentemente corrono continui rischi di degrado.
In particolare risultano in pericolo i siti geologici meno «percettibili» da parte dell'opinione pubblica, di progettisti, di amministratori, come un particolare livello stratigrafico od un raro affioramento di fossili.
Occorre quindi iniziare un progetto regionale di individuazione, valutazione, catalogazione e protezione dei siti geologici di rilevante interesse della Regione Abruzzo.
Infine appare fondamentale che tale progetto introduca il concetto di «sito geologico» della IUGS e dell'UNESCO nella legislazione ambientale regionale.

PAROLE CHIAVE: Geologia ambientale, siti geologici, Abruzzo

SUMMARY - The Abruzzi Region shows geological features mainly related to sedimentary, tectonic, geomorphological cycles. From the stratigraphic sequences (i.e. carbonatic shelf, arenaceous-argillitic turbidites, continental deposits) to the Apennines orogenesis, and from the erosion-karstic processes to the natural hazards features, the region exhibits a wide range of geosites.
Several of them are included in the numerous preservation areas of Abruzzi, considered an European "green region": 3 national parks, 1 regional park, 13 natural reserves. However, many other geotopes lie out of these areas, thus being at risk.
In addition, the existence of peculiar geotopes, not easely "perceptible" as geomorphological monuments, such as a cascade, a pinnacle, a rock arch, is to be outlined. These can be represented by a particular stratum or a palaeontologic outcrop and are undoubtedly of great scientific value.
Therefore all the above geotopes need a regional project for their characterization, listing and protection. Moreover, we suggest the introduction of the "geosites" concept in the Abruzzi environmental legislation.

KEY WORDS: Environmental geology, geosites, Abruzzi

1. – INTRODUCTION

The Abruzzi Region shows a considerable number of important geological sites, connected to sedimentary-stratigraphic, tectonic and geomorphological environment. The most interesting kind of rocks are the carbonatic ones, abundant in this region.

Many of these geological sites are included in protected areas, even if their scientific knowledge, listing, diffusion and real protection are not really realized.

The Abruzzi Region is today considered as the "European green Region" because three national parks, a large regional park and fourteen natural reserves are included in it.

Only one of the three national parks, the Abruzzi N. P. (44.000 ha) founded in 1922, is acting and operative. The other two, the Gran Sasso-Laga N. P. (143.000 ha) and the Maiella N. P. (73.000 ha), founded by the recent national law about protected areas

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TAB. 1 – Natural Reserves (geosites) already established by Abruzzi Region
– *Riserve naturali di tipo geologico già costituite dalla Regione Abbruzzo*

NAME	MUNICIPALITY	ha
Sorgenti del Pescara	Popoli (PE)	49
Zompo lo Schioppo	Morino (AQ)	1.025
Voltigno e Valle d'Angri	Ofena, Villa S. Lucia (AQ)	5.172
Gole del Salinello	Civitella Tronto (TE)	800
Calanchi di Atri	Atri (TE)	380
Grotte di Pietrasecca	Carsoli (AQ)	110

394/91, are being really constituted. The Velino-Sirente regional park (60.000 ha), even instituted with the same law, is in the same way coming true.

The Abruzzi Region has founded fourteen natural reserves and six of them are peculiar for important geological sites, as in evidence in tab. 1.

The instituted decrees, give really the reason for the N. R. foundation as geological value only in case of Atri badlauds, of Pietrasecca caves and partly of Zompo lo Schioppo waterfall. This happens because in the Italian environment field the biological culture prevails over the geological one.

Many interesting geological sites exists out of these protected areas and therefore at risk of being damaged. These sites need an immediate location and recording.

2. – WHICH ARE THE IMPORTANT GEOLOGICAL SITES?

The conceptual and methodological criteria for the editing of a regional inventory about important geosites, are numerous and heterogeneous (WIMBLEDON, 1990; AUTORI VARI, 1991; GONGGRIJP, 1992; WILSON, 1994; ARNOLDOUS-HUYZENDVELD *et alii*, 1995; VDOVETS, 1996).

By these contributions, the criteria that qualify the definition of a geological peculiarity or a geological monument or geotope or geosite of great interest, are the following:

– rarity and scientific value;
– the representation;
– accessibility and the enjoyment;
– vulnerability;
– landscape value ("natural beauty").

It is important, now, to specify the categories connecting the different geological sites. The ideas are different even in this case; in this paper the categories showed in tab. 2 are proposed.

3. – A FIRST PROPOSAL OF GEOLOGICAL SITES INVENTORY FOR ABRUZZO REGION

An inventory about the most important geological sites for Abruzzi Region, certainly unfinished, has been proposed for the first time, on the ground of literature data and of our territorial knowledge.

TAB. 2 – Geosites types
– *Categorie di siti geologici*

GEOMORPHOLOGY - Formation which indicate the morpho-evolutive history of a particular area (canyons, dolinas, glacial cirques, faults, landslides, volcanic morphologies) - Important formation for the landscape (pinnacles, erosions, geological and/or geomorphological monuments)
GEOLOGY - Interesting stratigraphic sections - Sections with particular sedimentary structures - Applied geology (quarries and mines) - Important tectonic and metamorphic structures
MINERALOGY AND PETROGRAPHY - Mineral deposits without an economic importance - Mineral deposits with economic importance - Rare mineral deposits - Lithotypes with scientific and/or economic importance
HYDROGEOLOGY - Important springs for water chemistry - Important springs for groundwater circulation - Waterfalls
PALEONTOLOGY - Fossil vertebrates - Fossil invertebrates - Fossil plants
PEDOLOGY - Main kind of paleosoils

From the proposed list is in evidence that there exist direcly "perceptible" sites, by experts but even by public opinion, planners and managers. The Abruzzi Region has decided to protect six important geological sites, since some time ago (tab. 1) and this is the proof of what we explained before.

Sites not easily "perceptible" exist, as a particular stratigraphic level or a rare outcrop of fossils, with the same scientific importance and the same need of protection.

3.1 – GEOMORPHOLOGICAL SITES

(AQ = L'Aquila, TE = Teramo, CH = Chieti and PE = Pescara - Provinces)

Erosion:

- Atri (calanques), Natural Reserve; TE
- Valle dell'Alento (calanques); CH
- Anversa Abruzzi (calanques); AQ
- Balzolo - Pennapiedimonte (rock arch - limestone); CH

Canyon:

- Gole del Salinello, Gran Sasso-Laga National Park; TE
- Gole di Celano, Regional Park Velino-Sirente; AQ
- Valle dell'Orta (I Luchi); PE
- Vallone di S. Martino (valle di S. Spirito); CH
- Gole del Sagittario; AQ
- Foce di Barrea; AQ
- Gole di S. Venanzio (Molina Aterno); AQ

Fig. 1. – Polje of Voltigno.
– Campo carsico del Voltigno.

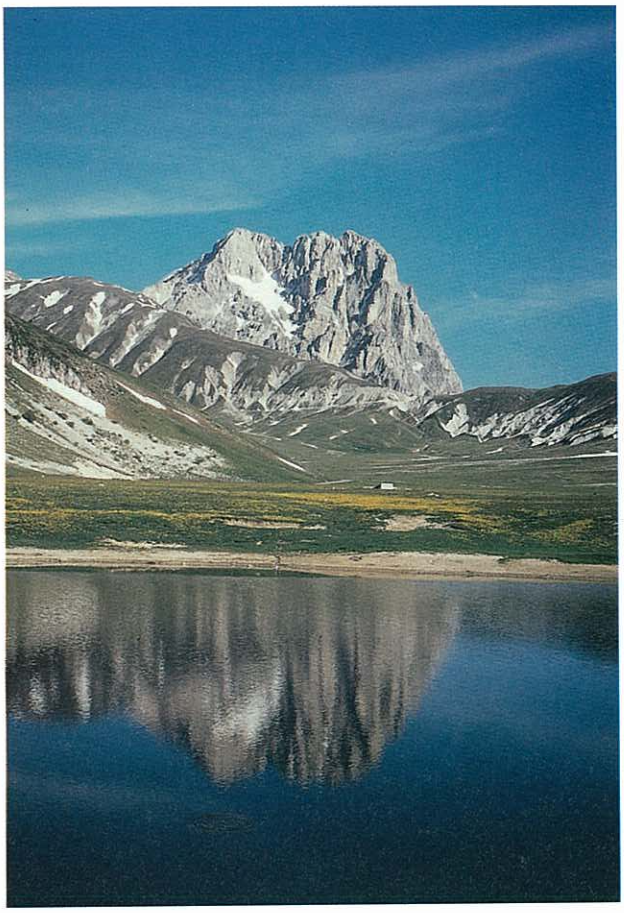

Fig. 2. – Campo Imperatore and Corno Grande (2912 m a.s.l.).
– Campo Imperatore e il Corno Grande (2912 m s.l.m.).

Karstic:

- Voltigno (polje); AQ (fig. 1)
- Amplero (polje); AQ
- Fossa Raganesca (dolina); AQ
- Fosso Spedino (dolina); AQ
- Montagna di Godi (dolina field); AQ
- Pietrasecca/Ovito-Cervo (caves), Natural Reserve; AQ
- Stiffe (caves-outcrop); AQ
- Quarto del Barone-S. Chiara (mixed alluvium-karstic formations); AQ

Glacial:

- Calderone (glaciers and snow field), Gran Sasso-Laga National Park; TE
- Campo Imperatore (glacial-karstic roof), Gran Sasso-Laga National Park; AQ (fig. 2)
- Campo Pericoli (glacial-geologic roof), Gran Sasso-Laga National Park; AQ-TE
- Fondo Femmina Morta, Maiella National Park; AQ

Fig. 3. – Capo Pescara Springs.

– Sorgenti di Capo Pescara.

• Valcannella (permafrost), Maiella National Park; CH
• Anfiteatro Murelle, Maiella National Park; CH
• Circhi Monte Greco (even archaeologic); AQ

Landslides:
• Frattura (Lago di Scanno); AQ
• Caramanico (valle dell'Orta), Maiella National Park; PE

3.2 – GEOLOGICAL SITES

Stratigraphy:
• Pietrasecca (Creta-Miocene); AQ
• Fonticelle (Pietrasecca) (Tortonian-Messinian); AQ
• Vallone Inferno (Corno Grande) (Trias-Lias); AQ
• Montagna dei Fiori (livello Bonarelli); TE
• Castelli - Rigopiano (ripple marks); TE
• Valle Giumentina (Quaternary); CH
• Monte Acquaviva, Maiella National Park; CH
• Bassa Valle dell'Orta-Bolognano, Natural Reserve; PE

Tectonic structures:
• Monte La Queglia (stress anticlinale); PE
• Faglia di Castel del Monte (fault); AQ
• Faglia del Parasano (fault), loc. S. Veneziano (seismic); AQ
• Claystones with microfolds (Gran Sasso-Laga National Park); TE

3.3 – MINERALOGICAL AND LITHOLOGICAL SITES

• Lecce vecchia (bauxite deposits); AQ
• Atri-Pineto (mud volcano - gaseous hydrocarbons); TE
• Ovindoli (solid hydrocarbons); AQ
• Tocco Casauria (solid hydrocarbons); PE

3.4 – HYDROGEOLOGICAL SITES

Springs:
• Capo Pescara (Popoli), Natural Reserve; PE (fig. 3)

- Vera (Paganica), Natural Reserve; AQ
- Acque Vive (Taranta Peligna); CH
- Lavino (sulphureous springs), Touristic Park; PE
- Zompo Lo Schioppo (springs-waterfall); AQ

Waterfall:

- Sfischia (Valle dell'Orfento), Natural Reserve; PE (fig. 4)
- Fiume Verde (Rossello); CH
- Fosso Cavata; TE

3.5 – PALEONTOLOGICAL SITES

Vertebrates:

- Scontrone (Tortoniano); AQ
- Palena (fishes and plants); CH

Invertebrates:

- Vallelonga (rudistids); AQ
- Focalone, Maiella National Park; CH

Plants:

- Torre dei Passeri Travertines (Valle del Pescara); PE

3.6 – PEDOLOGICAL SITES

Paleosoil:

- Andosoils of Aremogna (Roccaraso); AQ

4. – CONCLUSIONS

This inventory about important geological sites of Abruzzi Region, explained by this paper, consists only in a first step to the most important goal of geological heritage protection. It needs to organize detailed maps with an adeguate cartography and with environmental geology data, for each sites of the list and made right research on the territory to individuate other important geological sites.

On the ground of mature experiences in others European Countries, the individuation criteria should be more sophisticated.

An open, logical and with a scientific value inventory will be possible by degrees, and it will be an important instrument for the introduction of the "geosites" concept, as recommended from IUGS and from UNESCO, in the environmental regional legislation.

Fig. 4. – Sfischia Spring (Orfento valley).

– Sorgente della Sfischia (valle dell'Orfento).

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The inventory of the geological cultural heritage of the Latium Region (Italy)

Il censimento dei beni culturali a carattere geologico della Regione Lazio (Italia)

CASTO L. (*)

ABSTRACT - The results of a census of the Geological Heritage in the Latium region are described in the paper. The work was carried out by the Regional Center for the Documentation of the Cultural and Environmental Heritage of the Latium Regional Administration. The research was carried out in three experimental areas: Middle Tiber Valley, Alban Volcanic District and Pontina and Fondana Plains, it allows the recognition of 132 geotopes with high scientific value.

KEY WORDS: Geotopes, Catalogue, Lazio, Italy

RIASSUNTO - Vengono riportati i risultati della campagna di censimento e catalogazione dei Beni Culturali a carattere geologico condotta dal Centro Regionale per la Documentazione dei Beni Culturali e Ambientali della Regione Lazio. La ricerca, che è stata effettuata in tre aree campione del territorio regionale, Media Valle del Tevere, Distretto Vulcanico Albano, Pianura Pontina e Fondana, ha permesso di individuare complessivamente 132 geotopi di rilevante valore scientifico.

PAROLE CHIAVE: Geotopi, Catalogo, Lazio, Italia.

1. – INTRODUCTION

In 1981 the Lazio Region founded the Regional Centre for the Cultural and Environmental Heritage Documentation (CRD) which is a field of today's Assessorship at Politics for Culture, Spectacles, Tourism and Sport promotion. The CRD, for the law L.R. 31/91, has different and many tasks with the aim of promoting a better knowledge of the regional territory. The main activity, of census and catalogue, has been managed through 9 different subjects: archaeology, architecture, anthropology, history of art, geography, history, geology, botany and zoology. This activity has been developed in conformity with the Plan for census and catalogue of Lazio's cultural and environmental goods, which was passed with the Resolution of Regional Council n. 642 of May 16th 1979, that divided the Lazio Region in 8 sample areas.

The philosophic thought about this Plan is evident in the conclusions expressed at the end of this paper and formulated from the Commission "Census and Catalogue of Cultural and Environmental Goods" at the end of the First Regional Conference about the Cultural and Environmental Goods Policy, that took place at Rome in November 1977. The main aims of this Plan have been constantly considered and identified in protecting Cultural Goods and the cultural and natural heritage of the territory, with the aim of achieving good economic and politic management. There is in this Plan a new meaning for the concept of protection "no more as issuing of administrative measures for the simple goods preservation, but as an active protection even promoted and realized from the citizens with the consciousness of the necessity to defend and to put the common heritage to its best use".

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Knowledge of the territory and its diffusion are the main concepts in the Plan's philosophy. The territory can be considered as "real space where the societies work by their cultural abilities, in relation with natural environment" or as "a total container of Cultural and Environmental Goods", saving, in this way, the unity of the concept of Cultural good, considering the traditional division between man made and natural "goods".

Considering the naturalistic one, the Plan introduces the concept of geotope (without a perfect definition) to indicate operational guide-lines dividing these natural "goods" by disciplines (geological goods, mineralogical, palaeontological, botanical, fauna) and from a point of view of the complexity of the ecological system considered: single specimen, single populations, deposits, single taxonomic entities, phytocenosi, zoocenosi, whole ecosystems, geomineralogical and geomorphologic complexes, and geotopes, biotopes, areas, territories or part of them that are part of this naturalistic realities.

2. – CENSUS OF CULTURAL HERITAGE IN A GEOLOGICAL WAY

2.1. – CRITERIA OF SELECTION, SAMPLE AREAS.

The census of the geotopes of Lazio, which started in 1987 from a co-operation between CRD and ENEA (Environmental Department) (CASTO *et alii*, 1991), has been developed in three of the eight sample areas (indicated by the Plan): Media Valle del Tevere (area 8) (CASTO & ZARLENGA, 1992), Colli Albani (area 2) (CASTO & ZARLENGA, 1996) and Pianura Pontina and Piana di Fondi (area 4) (CASTO & ZARLENGA, 1997). The selection criteria adopted reflect the Wimbledon's classification of the "categories" (1990), relating this classification to the Italian legislation to the local geology and to the national context; the "Best Sites" the "Unique Sites" the "Firsts" and the "Patterns" have been considered.

The scientific value depends on the rarity (with regard to the formation process and to the scientific meaning in a regional scale); diversity; historical value and "key position" (for the scientific value); condition of the access route and accessibility (for the educational value); vulnerability (in relation to threats) and scenic value expressed as natural beauty. Determinate groups of goods have been selected: stratigraphic sections, sections with peculiar sedimentary structures, faults well evident, folds, fold systems, overthrusts, sections with important sedimentological evidence; applied geology (quarries and mines). Furthermore, mineral deposits with or without economic importance; rare mineral deposits; outcrops of particular effusive and intrusive rock types; important formations for the morphologic and evolution history of a particular area: river-terraces, sea-terraces, craters, cones of scoriae, caldera, karstic formations, geological and geomorphological monuments; beautiful landscapes; springs with importance for chemistry and the groundwaters circulation; fossil deposits with invertebrates, vertebrates and plants; the main natural history museums in the research areas (tab. 1).

2.2. – LINES OF THE RESEARCH

The methodology of the research has been developed in more phases which consist of:

1) bibliographic research

2) geomorphological prospecting, elaborated with remote sensing or by air photography supported by checks of country calibration

3) compiling the census cards.

Bibliographic research

This kind of research has been carried out during the preliminary phase, covering Authors of the last century and of the beginning of 1900, the later publications between the beginning of 1900 and 1960, and the latest synthesis of the last ten years.

The palaeontological part of this research (CASTO *et alii*, 1987; 1993; CASTO e CUGGIANI, 1993; 1993a) was very important and it has been the subject of a bibliographic survey made by CRD researchers, in 1985-86.

This census was published in 1987 and has been used for geotope research. The 1800-1900 references are related to the Media Valle of Tevere and the Colli Albani area, where the 89% of the publications are palaeontological or volcanological.

Publications between the two World Wars till the beginning of the 1960 concerned the Pianura Pontina (Blanc and Segre on Quaternary of Pianura Pontina and fossils of Grotte del Circeo) and Colli Albani, while the Media Valle of Tevere area was poorly represented; it was not well known from a geological point of view until the publication of geotopes census (CASTO & ZARLENGA, 1992) there had been a hiatus between the 1900 studies and the precise recent ones.

The studies of Monti Lucretili and the Geological Map of Italy (with the normal scale limitations) were the only specific work in that area.

TAB. 1. – Categories of geotopes
– *Categorie dei geotopi*

GEOLOGY
– stratigraphic sections
– sections with particular sedimentary structures
– rock sections which indicate particular phases and conditions of volcanic activity
– faults of a particular importance
– folds, folds system, overthrusts
– applied geology (quarries and mines)

PETROGRAPHY and MINERALOGY
– mineral deposits without an economic importance
– mineral deposits with economic importance
– rare mineral deposits

GEOMORPHOLOGY
– formations which indicate the evolution of the morphological history of a particular area: fluvial terraces, sea terraces, high structurals, craters, cones of scoriae, caldera, karstic formations, etc.
– geological and/or geomorphological monuments
– areas of landscape beauty

HYDROGEOLOGY
– springs important for water chemistry
– springs important for groundwaters circulation

PALAEONTOLOGY
– fossil deposits of invertebrates
– fossil deposits of vertebrate
– fossil deposits of plants

MUSEOLOGY
– main scientific museums in the investigated area

Remote sensing of geomorphology

The geomorphological elements which could have cultural significance had been highlighted by remote sensing with air photography (flight Lazio Region, 1982). The photo-interpretation has been supported by checks in the field.

The census card

Every geotope has been explained by a standard recording card so as to give synthetic information about the Lazio territory to different users (researchers, students, public managers, etc.) that might use the Regional Centre of Documentation archives. The card is composed of fields recording data about the topographic location (Province, municipality, placename, geographic co-ordinates, I.G.M. Sheet and Table – 1:100.000 and 1:25.000 –, which allow the georeferentiation), the description of the most important peculiarities, the scientific value, the preservational state, the stressors and the possible risks, the restraints that lay on the site and a foundamental bibliography about the same geotope.

One or more "compilers" have a reserved special space, for "key words", which come from the "International Lexicon of the Earth Science" (CARIMATI *et alii*, 1984), and the Pianura Pontina e Fondana area publication, from the "Interdisciplinary scheme of classification of the environmental and territorial documentation" (RALLO, 1994).

The census areas of the geotopes (D.C.R.642/79).

Area 8

This area is included in the territories of the following municipalities: Magliano Sabina, Collevecchio, Stimigliano, Forano, Poggio Mirteto, Ponzano Romano, Filacciano, Torrita Tiberina, Nazzano, Fiano Romano, Capena, Montelibretti, Montopoli in Sabina, Castelnuovo di Porto, Fara in Sabina, Riano, Sant'Oreste, Monterotondo; the first six of them are part of the Rieti Province, the others of Roma Province.

Media Valle del Tevere is part of this area, between Magliano Sabina e Monterotondo, also the west side of Monti Lucretili reliefs and the eastern part of Sabatinian volcanic reliefs.

From a country recognition sixty sites have been located and detailed on census cards in a short form.

Fifteen sites have geological evidence connected to tectonics and/or sedimentation (important relief faults, high-structural, sedimentary, clear and didactically useful structures); nineteen present elements referring to the stratigraphy and palaeontology and they are geotopes of primary importance for the study of geology of that zone; five are mineral springs distinguished for a particular chemistry and/or underground circulation of waters; sixteen has clear geomorphological elements: river terraces and/or erosion surfaces; four sites are connected to Sabatinian volcanism, and only one site (the "Sasso di Fiano") is in the landscape "beauty" category.

Area 2

This areas consists in seventeen Municipalities, all located in the Roma Province:

Albano Laziale, Marino, Castel Gandolfo, Nemi, Frascati, Rocca di Papa, Lanuvio, Ariccia, Monte Compatri, Colonna, Rocca Priora, Grottaferrata, Ardea, Monte Porzio Catone, Ciampino, Pomezia, and Genzano di Roma.

The main part of the volcanic district of Colli Albani is in this area; in Ardea and Pomezia Municipality, located on the coast there are sediments correlated with the Plio-Pleistocene of the perithyrrenian margin.

Fourtyfour sites have been selected during the census; twentyfour of them are geomorphological sites (volcanic cones and calderic depressions); nine are rock sites with peculiarities (rarity and/or clearness of exposition) and some of them are in active or disused quarries; five are sites where there are very important stratigraphic, tectonic and/or palaeontological elements; four are springs (one is the Squarciarelli, with historical importance), and two are places where mineralogical species has been discovered, with a great scientific value for rarity, for crystal size and/or for their perfection.

All can be considered as a landscape's beauty and they can be classified in that or in the other categories.

Area 4

This is an area which concerns ten municipality's territories, in Latina Province: Campodimele, Fondi, Latina, Lenola, Monte San Biagio, Pontinia, Sabaudia, San Felice Circeo, Sperlonga, and Terracina.

In this area is the main part of Pianura Pontina and Fondana and only a short part of Monti Ausoni, of Monti Aurunci (on the west side) and the Albano Volcanic District.

Twentyeight sites with cultural value have been selected by the inventory, twelve of them are in "hydrological goods" category (springs and lakes), seven have good elements for stratigraphic and structural geology of the area (geological section, palaeontological deposits, Monte Circeo is very important for the discovery of *Homo sapiens neandertalensis*), six are in the "geomorphological goods" category where is possible to identify the sea-terraces, karstic formations (some of them of landscape beauty), along the Sperlonga coast and inland of Terracina Commune (Campo Soriano). Two sites show the outcrops of the Laziale Volcano and, lastly, the Riparo Salvini is an historically and scientifically important geotope for the discovery of the stone industry of the Upper Palaeolithic.

3. – CONCLUSIONS

In the three sample areas examined, 132 sites have been identified that can be considered as "Cultural Goods". By investigation made in the field after the census, it has been discovered that some of them have disappeared (Cava di Galantina in Poggio Mirteto Municipality) or are really damaged as is the case with the historical peperino quarry, "Le Petrare", close to Marino, which is now a training wall for rock-climbers school. The lack of a real conscience about protection and evaluation of the geological heritage from the political authorities, together with the limited aesthetic sense, expression of poor basic culture, bring about damage to the landscape in areas where the high scientific value is connected with naturaness.

Situations like these are common in the area of Colli Albani, as the abusive discharges in the chestnut wood, in the area inside the Parco Suburbano of Castelli Romani or in the area of crumbling buildings.

The census of Geological "Goods" carried out from the Regional Centre of Documentation, should lead to the adoption of a policy recognising knowledge of territory and its utility, of instruments for a effective planning and use of the territory, as well and for the evaluation and protection of related cultural heritage.

The census, furthermore, even if it is limited (for the moment) to only 3 areas of Lazio Region, is based on guide-lines explained by the "Census Plan". It should alert public opinion about the importance of the geotopes in the region, wishing furthering the hope that the concept of geotopes could be part of the political and administrative culture of our country.

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Criteria for revealing geosites in an effort to compile a global list
Criteri per rivelare i geotopi nello sforzo per la compilazione di una lista globale

LAPO A.V. (*)

ABSTRACT - The following criteria are useful for revealing geosites in an effort to compile a global list: best or largest appearance of a geological phenomenon; rare and unique; first recognition and mining; patterns; oldest and youngest appearance of a geological phenomenon; significant on-going geological process; documented event; geodiversity.
A sufficient exposure of the territory and, in the case of geomorphological sites, an adequate morphological manifestation of landforms are also required for this purpose.

KEY WORDS: Geosite, geological heritage, Global list of geosites.

RIASSUNTO - I seguenti criteri sono utili per rivelare geotopi nello sforzo per la compilazione di una lista globale: la bellezza o l'ampiezza del fenomeno geologico; la rarità e l'unicità; la prima identificazione o scavo; l'esempio; la più antica o la più recente apparizione di un fenomeno geologico; un significativo processo geologico in evoluzione; l'evento documentato; la geodiversità.
Vengono anche richiesti a questo scopo una adeguata esposizione del territorio e, nel caso di siti geomorfologici, una adeguata manifestazione morfologica del paesaggio.

PAROLE CHIAVE: Geotopi, patrimonio geologico, lista globale dei geotopi.

1. – GLOBAL LIST

It seems that a choice of criteria for revealing the geosites is a preliminary stage for compiling a Global list of geosites, now co-ordinated by the new IUGS Global Geosites Working Group (GGWG). For this purpose, first of all an experience of work for the implementation of "The UNESCO World Heritage Convention" (1972) might be useful. Then, according to "Operational guidelines for the implementation of the World Heritage Convention" (1988), in order that "a geological or geomorphological property" (in other words, a geosite) should be of outstanding universal importance, it must meet one or more of the following criteria:

1) be outstanding examples representing the major stages of the Earth's evolutionary history; or

2) be outstanding examples representing significant on-going geological processes...; or

3) contain superlative natural phenomena, formations or features..." (quoted from JOYCE, 1993).

At the same time, for solving the problem under consideration W.A. WIMBLEDON's idea (ANDERSEN *et alii*, 1990) of discerning the following "categories" of geosites is very important:

1) best sites;

2) unique sites;

3) firsts;

4) patterns.

In fact, there are rather definite criteria for revealing geosites and that is why it seems that WIMBLEDON's early proposition along with "Operational guidelines...", quoted above, may be used as a basis for further development (WIMBLEDON *et alii*, 1997). So I will try to take some steps in this direction using well known geosites as examples.

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2. – BEST SITES

There is no question, that "best" is a very important criterion for revealing the geosites. According to this criterion, we have to reveal geosites of every kind best in the World. It seems that a detailed typology of the geological heritage sites (LAPO & PASHKEVICH, 1996) will be useful in this connection. The main problem is to determine the best geosite for every subtype of this typology. Certainly, it is rather difficult, but I think we must develop the research just along this line.

At the same time, in some cases it is necessary to give a preference to something that is the largest. For example, the Shunga Deposit of shungite in Karelia (Russia) is the largest in the World as to accumulation of carbonaceous matter in the Lower Proterozoic, the Popigai Astrobleme in the North of Siberia is the largest (100 km in diameter) in the World among well exposed Phanerozoic Astroblemes, and the Flint-Mammoth Cave (Kentucky, USA) is the largest (341,1 km long) cave in the World. In other words, these are "superlative natural phenomena, formations or features" (see above).

Therefore, best or largest appearance of a geological phenomenon is one of the proposed criteria for revealing the geosites.

3. – UNIQUE SITES

Examples of "unique sites" are a natural nuclear reactor in Oklo, Gabon, and such a unique cosmic event geosite as the Tunguska (North of Siberia) phenomenon of 30.06.1908. But it is necessary to take into consideration, that it may turn out that in future it will be merely the first observation of the phenomenon, which in its turn will become rare but not unique. Therefore, it seems that it will be better to call this criterion "rare and unique".

4. – FIRSTS

Concerning "firsts", it could be better to say in this case "first recognition", meaning the first recognition of one or another geological phenomenon. There are some examples of this kind in the paper quoted above (ANDERSEN *et alii*, 1990). In addition to them some other examples could be given. There are holostratotypes of stages, such as the Gzhelian near Moscow; there are also initial localities of definite kinds of fossils, such as the Ediacara Vendian biota in Australia, or, another thing, initial localities of well-known minerals, such as ilmenite in the Ilmen' Mountains in the Urals, and rocks, such as sviatonossite in the Sviatoi Nos Cape on the Baikal Lake. The oldest mining localities are something of a specific case, but in fact they are also suited to the idea of "the firsts". So we can call the last case as "first mining", and as a result the criterion under discussion in general may be called as "first recognition and mining".

5. – PATTERNS

As to "patterns", WIMBLEDON has defined them as geosites "which demonstrate the salient or significant features, be they hard or soft rock or landform, which occur in or typify an area, large or small" (ANDERSEN *et alii*., 1990). Key sections provide good illustration of using this criterion for revealing geosites.

In addition to WIMBLEDON's criteria, mentioned above, it seems to be pertinent to discuss some other geological criteria. Let us consider them one after another.

6. – OLDEST AND YOUNGEST

The first of them is the oldest and the youngest appearance of a geological phenomenon. In fact, there is a particular case of the criterion "to be outstanding examples representing the major stages of the Earth's evolutionary history" mentioned in "Operational guidelines..." (see above). In this respect the simplest case is fossil sites, among which the oldest appearance means localities of remains of first representatives of the major taxa of biota, and the youngest one - localities of remains of last representatives of extinct taxa. Using this criterion, one can reveal East Pilbara ("North Pole") in Australia, the oldest (3500 Ma) microfossil site in the World. It is also true for sites of the Isua Supracrustal Belt in SW Greenland, where the oldest rocks in the World (3900-4100 Ma) are exposed. An exactly converse example is the Tyrnauz Deposit in the Caucasus where one of the youngest granite in the World, dated at 2,48 Ma, is represented.

7. – GEOLOGICAL PROCESSES

A significant on-going geological process, as it was mentioned in "Operation guidelines...", may be also

used as one of the criteria for revealing the geosites. One example of such kinds of geosite, the on-going Oklo natural nuclear reactor, was mentioned above. As another illustration we refer to localities of present-day mineral formation, such as salt lakes. It is also true for localities of present-day formation of rocks, for example, rather exotic ones, as geyserite and travertine. Otherwise, an apt example is also the great deltas, where accumulation of recent turbidites takes place. Finally, localities of manifestation of recent tectonics are good examples of geosites which may be revealed using this criterion.

8. – DOCUMENTED EVENTS

The next criterion for revealing geosites is based on a fact that one or another geological event was observed there by inspection and documented immediately after it occurred. The geosite of the cosmic phenomenon at Tunguska of 30.06.1908 has been already mentioned above. Other examples are a group of meteoritic craters in the Sikhote Alin Ridge (the Far East of Russia) resulting from a rain of meteorites (dated 2.02.1947), and the Proval Bay of the Baikal Lake which was formed as a result of a disasterous earthquake (January 10-12, 1862).

9. – GEODIVERSITY

Geodiversity is the last, but not least, of the discussed criteria for revealing geosites. By this is meant a great diversity of these or those attributes of a particular geological phenomenon. It may have a great diversity of minerals in the geosite (e.g., in the Khibiny and Lovozero Alkaline Massifs in the Kola Peninsula there are more than 500 minerals), or a great diversity of fossils (e.g., more then 100 species of foraminifers in the Sterlitamak Shikhans in Bashkiria, or a great diversity of rock types (it makes no difference whether they are sedimentary, magmatic or metamorphic).

10. – SUMMARY GEOCRITERIA

All-in-all, the following geological criteria are useful for revealing geosites:

– best or largest appearance of a geological phenomenon;

– rare and unique;

– first recognition and mining;

– patterns;

– oldest and youngest appearance of a geological phenomenon;

– significant on-going geological process;

– documented event;

– geodiversity.

To be included in a global geosite list a geosite should conform to one or more of the criteria mentioned above. It seems that a sufficient exposing of the territory and, in the case of geomorphological sites, an adequate morphological manifestation of landforms are also required for this purpose.

11. – COINCIDING VALUES

All the criteria discussed above are geological ones. But in some cases for sites of geological interest various non-geological criteria should also be taken into consideration. These criteria may be the following: picturesque landscape, great present-day biodiversity and the presence of endemics, as well as the presence of archaeological subjects.

The first example of such geosite is the Baikal Lake which is equally interesting as a very deep contemporary rift depression, the largest body in the World of the purest, the most transparent fresh water and, finally, as a site of very diverse endemic fauna.

And the second, tragic example, which is appropriate to be recalled here, in Italy, is Pompeii. It is universally known, that it is not only the archaeological site of World significance, but also a geosite, owing to the products the violent Vesuvian eruption which took place one day in year 79 A.C.

Certainly, such kind of sites are considered as sites of other, non-geological, categories of natural and cultural heritage, but they also have to be included in a global list of geosites.

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A holistic approach to conserving the Earth's natural heritage
Un approccio olistico alla conservazione del patrimonio naturale della Terra

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ABSTRACT - Earth heritage conservation in England has evolved from a predominantly site-based system of identification, protection and management of key sites. Recent strategic approaches now emphasise the need to integrate a site based system with a wider programme of engendering support amongst influential landusers, government and the wider public. A review of other national approaches shows that a common overarching aim exists - namely, to ensure that the best of the Earth's rocks and landforms are protected and valued. All methodologies, including that used in England, are recognised as alternative and equally valid ways of achieving this aim. It is argued that the need for sites, and the need for greater education in Earth heritage conservation are complementary. International 'guide' organisations, such as ProGEO, are vital to help each country to achieve the common aim of Earth heritage conservation by the method most appropriate to their national situation.

KEY WORDS: Geology, conservation, England

RIASSUNTO - La conservazione del patrimonio della Terra in Inghilterra si è evoluta a partire da un sistema di identificazione, protezione e gestione dei siti chiave prevalentemente basato sui siti. I recenti approcci strategici enfatizzano ora la necessità di integrare un sistema basato sui siti con un più vasto programma di supporto alla produzione tra i maggiori sfruttatori del suolo, il governo ed il pubblico più in generale. Una rassegna degli altri approcci nazionali mostra che esiste uno scopo comune a tutti: praticamente, assicurare che i più bei paesaggi e le più belle formazioni rocciose della Terra siano protetti e valutati. Tutte le metodologie, comprese quelle utilizzate in Inghilterra, sono riconosciute come metodi alternativi ed egualmente validi per raggiungere questo scopo. Viene sostenuto che la necessità dei siti e la necessità di una maggiore educazione alla conservazione del patrimonio terrestre sono complementari. Organizzazioni internazionali «guida», come ProGEO, sono essenziali per aiutare ciascun paese a raggiungere lo scopo comune della conservazione del patrimonio terrestre con il metodo più appropriato alla specifica situazione nazionale.

PAROLE CHIAVE: Geologia, conservazione, Inghilterra

1. – A COMMON VALUATION OF THE EARTH'S GEOLOGICAL HERITAGE.

The desire to ensure that the best of the Earth's rocks, landforms, minerals and fossils are protected and valued is central to all approaches to conserving our geological and geomorphological heritage. This common goal has involved people worldwide, in government, academia and in local communities, working toward a greater appreciation of geology and protection of its most important sites.

The rationale for geological or Earth heritage conservation has been explored in other places (WILSON, 1994; ELLIS *et alii* 1996), but the main components are:

– recognition that geology and landscape are intrinsic parts of our natural world;

– recognition that the Earth has had, and continues to have, a fundamental influence on civilisation through our interaction and use with rock, mineral and the land itself;

– the need for sites for research and education to advance our scientific and technological understanding, and

– a need to engender a wider understanding of the benefits that knowledge of past geological environments brings, and the lessons for the future that can be learnt from them.

Whilst the aims of Earth heritage conservationists are broadly similar, their methods are not. This is in many ways a result of national inheritance, as conservation practice is evolving in different countries in different ways, following separate legal and cultural patterns.

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Earth heritage conservation is in all cases, however, essentially a field-based subject. This is primarily a function of the need to view the geological record in context and related to this, the recognition that how we read this record and what we make of it (the theoretical and technological aspects) are rapidly evolving. Because of its field (and therefore site) basis, the practice of Earth heritage conservation tends to have strong links with other field-based conservation practices such as wildlife and archaeology. In consequence, Earth heritage conservation is practiced in many countries by nature conservationists and any legal recognition is through nature conservation legislation. Equally, many geological and landform sites are linked more to landscape features and values, and in some countries, there is a traditional link with landscape protection, such as national parks and monuments. This difference between the wildlife/archaeological (scientific) approach and the landscape (aesthetic) approach has often lain at the heart of different viewpoints on the methodology of achieving the aims of Earth heritage conservation.

Earth heritage conservation in Britain has always been an integral part of nature conservation, and its aims and methodology have been shaped accordingly. However, in recent times, the methodology of Earth heritage conservation in England (and in Scotland) has been revisited. This has shown that both the scientific and aesthetic aspects of Earth heritage and more widely, nature conservation, can work together to achieve conservation aims.

2. – EARTH HERITAGE CONSERVATION IN GREAT BRITAIN.

The conservation of geological and geomorphological features in Britain has a statutory basis. A network of sites or 'geotopes' has been established which are protected by national law (Wildlife and Countryside Act, 1981). These geotopes form part of a network of important nature conservation sites known as 'Sites of Special Scientific Interest'. English Nature, the national body responsible for nature conservation (including wildlife conservation) in England since 1991, has a duty to identify and safeguard the geology and geomorphology of this network from potential threats such as development, coastal defences and general degradation.

The origin of this legislation lies in post-World War II Britain when much of Britain's legal system and land use policies were reviewed. The 'Wildlife Conservation Special Committee' was set up to investigate and advise on nature conservation across Britain. They reported in 1947 that there was a need to safeguard special areas exhibiting geological and physiographical features. This far-sighted recommendation was included in the National Parks and Access to the Countryside Act 1949 which first set up the SSSI system.

Today, approximately 3000 nationally important geological and geomorphological sites exist in Great Britain, 1300 of which are in England. These top sites were identified by a structured review of Earth science sites which worked on the basis of distinct fields of interest. The full rationale and methodology for this appraisal of British Earth science sites, known as the 'Geological Conservation Review', has recently been set down formally for the first time (ELLIS *et alii*, 1996). Examples of these fields include stratigraphy, structural geology, igneous geology, coastal geomorphology and Mesozoic vertebrata. Within these broad areas, specific 'blocks' of sites were identified, for example, Wenlock, Variscan Structural sites, Caledonian Igneous sites, Cave sites and Jurassic-Cretaceous Reptilia sites. All were selected on the basis of detailed advice from the foremost researchers in each field.

Although some SSSIs are conserved as nature reserves on both a national and local basis, most are owned and managed by private individuals or companies. Conservation of sites is achieved through national development planning law and working with site owners to maintain and enhance the interest of the site and to promote its use for education and research. Planning authorities in Britain must take into account the national importance of SSSIs when deciding applications for development on or near a site. English Nature will normally advise the planning authority on the impact of a proposed development on the site, and where a development would damage the interest, have powers to prevent the planning authority from allowing that development.

For each SSSI a number of operations are also identified which the owner cannot undertake without first consulting English Nature. An example is the use of spoil from an old mine to repair tracks, where the spoil might contain important, rare minerals.

Whilst the system of sites in Britain, both at the national and regional level (RIGS), is adequate to represent and maintain the key elements of British Earth science, threats to these sites continued at a high level throughout the 1980's and into the 1990's. As a consequence, a great deal of time was needed to main-

tain and manage the sites. Detailed research has provided a series of technical solutions to maintain the interest at many different types of site (NCC, 1990b; ENGLISH NATURE, 1993), reducing management costs. The experience of English Nature in maintaining the SSSI, series however, identified that the maintenance of a site series alone was insufficient to achieve the overall aim of a wider understanding and valuing of the Earth science as well as protection of key elements.

In a system where sites are offered absolute and total protection, there is less need for public or other support. However, the British system does not afford guaranteed protection to nature conservation sites. Decisions on competing and threatening uses of these sites are taken by local planning authorities, and although the legal system affords protection, it may be decided that other interests outweigh the importance of the geology. Therefore, even in a site - based system as in England, there is a need for raised awareness and education. Developers, landowners, planners, politicians and the general public are generally unaware of the rationale and need for conserving our Earth's natural heritage of rocks, minerals, fossils and landforms. As a result, there is little public support for Earth heritage conservation in comparison to wildlife or archaeological conservation. The need to develop greater public awareness therefore underpins the direction that Earth heritage conservation has taken in England.

In 1990, the NCC published a cohesive strategy which for the first time directed and focused work on conserving the country's Earth science resource (NCC, 1990a). Six themes were laid down in the strategy, and in the following six years, these have been taken forward successfully by English Nature (Tab. 1). Since this strategy was introduced, three significant developments have shaped English Nature's approach to conserving the national heritage of Earth science and helped us to integrate the subject of Earth science conservation with related subjects such as wildlife, archaeological and landscape conservation.

The 1992 Earth Summit in Rio de Janeiro, Brazil placed the concepts of **sustainable development and biodiversity** on the international agenda. **Agenda 21** places emphasis on Government, business, the voluntary sector and individual citizens to participate in the formation of national and local strategies for sustainable development. This provides tremendous opportunities for Earth science conservation if it is regarded as part of the wider natural resource.

The Malvern International Conference on Geological and Landscape Conservation (1993), strengthened links between nations and promoted the appreciation of Earth resources and processes and their sustainable use. International co-operation and sharing of expertise is key to progressing Earth science conservation, and English Nature has participated both with the Malvern Task Force and now with ProGEO.

In England, English Nature has in the last few years embraced a holistic, 'natural world' view of nature conservation. We have reviewed our whole approach to wildlife and Earth Science conservation using the theme of Natural Areas (DUFF, 1994). Natural Areas are tracts of land, unified by underlying geology, landforms and soils, which display characteristic vegetation and species, and support broadly similar patterns of landuse Because the character of Natural Areas depend on their underlying geology and geomorphological processes, this creates links between

TAB. 1. – Strategic themes of the 1990 Earth science strategy for Great Britain, and achievements against each theme, 1996

– Temi strategici della strategia scientifica per la Gran Bretagna del 1990, raggiungimento di ciascun obiettivo nel 1996

1. *Maintaining the SSSI network as SSSIs*	Notified 97% all identified GCR sites in England Specialist management advice on sites
2. *Expanding the RIGS network*	Co-ordinated development of a national network of locally important sites
3. *Developing new conservation techniques*	Commissioned work on new engineering techniques including techniques for coastal managed retreat, quarries and road cuttings
4. *Improving site documentation*	Produced site management documents for all Earth science SSSIs in England
5. *Increasing public awareness*	Journals, books, leaflets and Earth Heritage magazine
6. *Developing International links*	Assisted with Malvern International Conference and Malvern Task Force

the geological and other aspects of the land, and importantly, provides opportunities to create closer working links with land managers such as farmers and wildlife conservationists.

To take the 1990 Strategy forward, English Nature have recently launched a new strategy with five strategic themes (Tab. 2) (ENGLISH NATURE, 1996; KING *et alii*, 1996a; KING *et alii*, 1996b). These themes take into account the new conservation priorities, building upon the foundations created in achieving the 1990 strategy. The conservation of Earth science sites using this approach is a significant advance on a solely site-based, geotope method. It bases itself on people as well as sites, such that in Britain, the term Earth **heritage** conservation has replaced 'Earth science conservation' and 'geological conservation'.

3. – COMPARISON OF METHODOLOGIES USED IN OTHER COUNTRIES

Conservation of geological features in England has developed from a mainly site-based system towards one in which the system is supported through wider appreciation of the need to conserve the Earth's heritage. Other countries have analogous systems. Conservation of Earth science sites in Romania is viewed as part of the nature conservation resource, with protection through a system of National Monuments (GRIGORESCU & NORMAN, 1990). Some countries such as Canada and Spain, have stringent regulations in specific areas of conservation, such as protection against irresponsible fossil collecting (NORMAN, 1994; ALCALÁ & MORALES, 1994). In Germany, the geotope concept (STÜRM, 1992; WIEDENBEIN, 1994) covers over ten thousand sites, protected on a regional basis, although no national overview exists. This system is more comparable with the British system as these sites are viewed in a holistic sense as part of the cultural heritage of the region. They are also increasingly being used as an educational and amenity resource, for example the 'Geo Zentrum' of the Eifel Region of western Germany, which utilises the superb volcanic maars and fossiliferous rocks of the area as well as its mineral springs.

In contrast, countries such as Slovenia and New Zealand have no specific Earth heritage legislation, and support for geological conservation has been sought in order to justify selection and conservation of a systematic series of sites. In Slovenia, little protection or support exists for geological sites amongst government, and public support is seen as a necessary prerequisite to achieving national governmental legal protection (HLAD, 1996). In New Zealand, earth science

TAB. 2. – Summary of aims of the 1996 Earth heritage strategy for England
– Sommario degli obiettivi della strategia per il patrimonio della Terra per l'Inghilterra del 1996

Theme 1	Managing and safeguarding the resource Having a set of SSSIs and RIGS, we will now concentrate on the positive management of these sites, enhancing their potential use for others
Theme 2	Integrating Earth heritage and the holistic approach The Natural Areas approach as outlined can be used to integrate Earth heritage interests more directly into key nature conservation schemes. This will include assessing the resource against sustainability criteria.
Theme 3	Influencing the influencers We will continue to press for increased recognition of the importance of Earth Heritage conservation with local and central government, and major developers. We will provide best practice examples to planners, offer training schemes, and forge working partnerships, following the principles of Agenda 21. For example, we are working with mineral extraction companies (particularly aggregates which is the largest sector) to achieve a better understanding and environmental performance by the industry through joint training and research.
Theme 4	Raising awareness One of the major problems for Earth heritage conservation remains the need to increase public support. We will use promotional methods to achieve this, through our targetted magazines, publications and media such as press, television, and local interpretation centres
Theme 5	Involving the public We also need to involve the public in Earth heritage conservation, to increase their interest and enjoyment of the subject. We will create new local nature reserves with local communities and look to improving links with museums, geological societies and schools

conservationists are directly lobbying government for inclusion of geological and geomorphological sites within nature conservation legislation (BUCKERIDGE, 1994).

4. – INTERPRETATION

Whatever methodology is used by individual groups and nations, the end aims are similar and in line with those outlined earlier. The Malvern International Task Force for Earth Heritage Conservation, for example, deals mainly with involving people in general support for the concept of Earth heritage conservation, and proposes that the subject is concerned with *"sustaining the part of the physical resources of the Earth that represents our cultural heritage, including our geological and geomorphological understanding and the inspirational and aesthetic response to the resource"* MALVERN International TASK FORCE FOR EARTH HERITAGE CONSERVATION, 1996). The last part of this definition (our emphasis) embraces both the pure scientific and the wider natural world approach of public education and enjoyment. Equally ProGEO, which emphasises the need to protect important geological sites, has objectives which include '*the conservation of Europe's rich heritage of landscape, rock, fossil and mineral sites*', providing information to a wider public and '*an integrated approach to nature conservation, promoting a holistic approach to the conservation of biological and physical/ geological phenomena*' (PROGEO, 1996).

Regardless of whether a site-based system for conservation is in place or not, it is important to achieve in addition, a wider appreciation of the value of sites.

5. – CONCLUSIONS

The common aim of all Earth heritage conservationists is a wider appreciation of the value of the Earth sciences and the conservation of the most important geological sites.

lish Nature have worked towards this aim by identifying a series of national sites which are protected in legislation which promotes proper management by landowners. The selection and management of these sites, as laid out in NCC's 1990 strategy was a firm foundation but formed only part of the conservation aims. In the long term, in English Nature, we believe that the key to conserving any network of sites is to place emphasis on **using** them to increase public appreciation and awareness of geology's value as part of the overall natural and human heritage.

The English experience is, however, only one method of achieving our common goal. Each nation has its own unique culture and legal system, and therefore different methodologies may be more suitable. Each country may take a different route to reach the same goal, for example one country may place more emphasis on public education and non-legal methods of safeguarding our heritage. Another state may require, or be able to implement, stronger site - based protection. All routes are, however, equally valid if the end aim is achieved. The benefits of a greater awareness of these different national experiences are immense. To paraphrase the Latin saying, '*mille via ducunt hominem per secula Roma*'- All roads lead *from* Rome.

Individual national and international organisations may then have different roles as expert 'guides' along distinct parts of these routes, sharing experience and fostering common goals. The role of ProGEO may for example lie more in advising and supporting the development of a coherent network of international 'Geosites' in Europe. The Malvern Task Force is a group which is developing wider public support and understanding of Earth heritage conservation internationally. Both these and other roles (such as an 'overseeing' function, something which a body such as UNESCO might perform) will be vital and complementary in achieving a common and agreed aim - the conservation of the Earth's rocks and landforms as part of our overall natural and human heritage.

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Inventory of glacial relief forms in Serbia and necessity for their protection

Il catalogo delle forme glaciali dei rilievi in Serbia e le necessità per la loro protezione

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ABSTRACT: In this paper we give an overview of the reserach project titled Glacial Relief in Serbia. Research activities have been focused in the area of Sar planina and Prokletije where majority of glacial relief forms are situated. We emphasize insufficiency of the number of properly protected objects of geological heritage. We also suggest a number of specific forms of glacial relief that need to be protected: entire glacial series situated on vertical profiles of slopes, such as cirques with multitude of glacial lakes. Additional value of these areas are numerous rare and endangered plant and animal species and their ecosystems.

KEY WORDS - Inventory; Glacial Forms; Protection; Serbia;

RIASSUNTO - In questo lavoro vengono fornite informazioni riguardo al progetto di ricerca intitolato Rilievi Glaciali in Serbia. Le attività di ricerca sono state focalizzate nell'area di Sar planina e di Prokletije dove è situata la maggior parte delle forme glaciali presenti sui rilievi. Si evidenzia l'insufficienza del numero degli oggetti del patrimonio geologico correttamente protetti. Inoltre si suggerisce un numero di specifiche forme del rilievo glaciale che necessitano di protezione: serie glaciali complete sui profili verticali dei pendii, come i circhi con numerosi laghi glaciali. Numerose specie di piante e di animali rari e minacciati ed i loro ecosistemi rappresentano dei valori aggiuntivi.

PAROLE CHIAVE - Inventario; Forme glaciali; Protezione; Serbia.

1. – INTRODUCTION

Protection of geological heritage in Serbia has not been receiving proper attention so far. Necessity for protection of geological objects (STEVANOVIC, 1950) and paleonthological remains (PRIBI, 1961) has been emphasized on many occassions, however, with exception of occasional inclusion of interesting specimens in museum collections or introduction of protection for certain objects, little has been done for this purpose. A number of speleologic objects were placed under protection in 1949: Zlotska pecina, Prekonoska pecina, Ravna pecina and Propast chasm, Radoseva pecina - Velika Atula and Gaura Mare - Velika pecina. Petnicka pecina was protected in 1950, Ravanicka pecina in 1951, Potpecka pecina in 1953, Samar pecina and natural bridge Samar in 1955, natural bridges in canyons of Vratna and Zamna in 1957, Djavolja varos in 1959, and geologicalal sites Lojanik and Prebreza in 1963. Number of protected geomorphologic objects rapidly increased in the period 1970 - 1990 so that today we have some 70 geological objects under protection, mostly as natural monuments. Most protected objects belong to the group of karst phenomena (holes, caves, natural bridges, stone windows, gorges and canyons, waterfalls, bygrenic beds, springs and wells, etc.). Only a small number of the objects under protection regards the elements of geological heritage

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(geotectonic, stratigraphic, hydrogeological, petrographic, mineralogical, palaeontological). The fact that there is only 70 geological and geomorphologic objects, among some 1.300 protected in Serbia, clearly shows that this number is much too small and absolutely insufficient for presentation of extraordinary values of geological diversity of Serbia. There is no doubt that in future efforts aiming at protection of nature we will have to pay greater attention to protection of geological and geomorphologic heritage, which include pedological and archeological values. One of the first steps in this direction is joining of the Institute for the Protection of Nature of Serbia to the European Association for Conservation of Geologicalal Heritage, which has been promoting the ProGEO project over the last few years. This Association has recommended this project to be carried out by competent institutions and experts in geological sciences at the level of individual countries, followed by coordinated joint efforts aiming at production of unique European list of geological heritage. Being the only institution in Serbia in charge of protection of nature, the Institute for the Protection of Nature has launched an initiative for establishment of the National Council for Geological Heritage in charge of preparation and adoption of long term policy in the filed of protection of geological heritage and definition of criteria for selection of objects and uniform methodology for protection of geological objects. Here is a suggestion concerning protection of representative sites featuring glacial relief forms, as a special addition to the project of protection of geological heritage which has yet not been placed under protection.

2. – GLACIAL RELIEF IN SERBIA AND ITS PROTECTION

JOVAN CVIJIC opened a new chapter in the history of geomorphological science when in 1891 he predicted presence of traces of glacial period in the area of Ljuboten (Sar planina) and carried out a thorough study of glaciation processes in Rila (1897). During the course of his work (1891; 1897; 1899; 1903; 1913; 1914) JOVAN CVIJIC established the main characteristics of glacial relief present in the mountains of the Balkans. Another researcher who produced groundbreaking results in this field was NIKOLIC (1912; 1913; 1914; 1914a), who concntrated his research efforts on the traces of old glaciers on Sar planina, Korab, Kopaonik, Stara planina and Suva planina. Other Authors who wrote about glacial relief on our highest mountains Sar planinma and Prokletije were MILOJEVIC (1937), endash Prokletije, RADOVANOVIC and NIKOLIC (1959) - Prizrenska Bistrica river basin, RSUMOVIC (1960) - glacial traces on Golilja mountain. Among recent research projects the following definitely deserve to be mentioned: GAVRILOVIC (1970; 1976) - mountains of eastern Serbia (actually, the whole of Serbia), PETROVIC (1979) - glacial relief on mountain Mokra Gora, MENKOVIC (1972; 1978; 1985; 1989; 1994) - Prokletije, Sar planina, Koritnik, Djeravica, BELIJ (1994) - the north-eastern side of Sar planina.

However, the times of fierce competition and great scientific discoveries pertaining to glacial geomorphology of the Balkans belong to the past. Our knowledge of glaciation in the mountains of Serbia is nowadays relatively profound and well systematized. There are minor traces of glaciation on many mountains of Serbia (Kopaonik, Golija, Suva planina and Stara planina), however the regions displaying the most prominent examples of glacial relief are situated on Sar planina and Prokletije, the highest mountains of Serbia and mountains with most emphasized glaciation during Pleistocene. Prokletije were the major center of glaciation in the Balkans during the Pleistocene. The snow-limit was situated at altitude between 1.400-1.500 m and vast mountain areas above this limit were under perpetual snow and ice. Large cirques formed in preglacial spring area produced glaciers which descended down the mountain slopes. The largest glacier, of valley-type, composite and very ramified is situated in the river basin of Pecka Bistrica. It came down to Metohija valley and left sediments of frontal moraines, 530 m thick, on the basis of which was calculated its length of 25 km. In the spring area of Decanska Bistrica river a ramified valley glacier, which is the second largest glacier with its length of about 20 km, was formed. There was a 14 m long glacier in the spring area of Erenik river and another 12 m long glacier in the river basin of Locanska Bistrica. On Rusolija and Zljeb plateau there was a karst-type glacier with numerous hanging glacial tongues. The only valley glacier found on Mokra Gora mountain is the one situated in Crna reka, at the same time there were cirques and hanging glaciers between mountain peaks. Leaving aside glacial traces in carbonate base (Hajla, Rusolija, Zljeb, Koprivnik, Mokra Gora), where typical features of glacial relief have been deformed and defaced, the best preserved glacial traces are to be found in spring areas of Decanska Bistrica and Erenik rivers. The following objects have been suggested for protection as objects of geological heritage: cirques surroun-

ding Djeravica and those in spring areas of Erenik and Koznjarska Bistrica rivers, tributaries of Decanska Bistrica and 10 glacial lakes, numerous morain ramparts and randomly scatterred erratic blocks. Composite carbonate cirque on the north side of Nedzinat, with Veliko and Malo Nedzinatsko lake, has all the qualities of an exquisite object. Establishment of their boundaries and definition of the regime of protection are planned as a part of activities of the Institute for Protection of Nature of Serbia pertaining to preparation of documentation necessary for planned establishment of the national park \ldblquote Prokletije\rdblquote. Being morphologically more simple, Sar planina underwent glaciation mostly on the north slopes, above 1.600-1.700 m. There were numerous cirque glaciers in the north-eastern part of the mountain (Lepenac river basin) and some of these descended to the bottom of the river valley. The largest one was Sirinic, 6-7 km long.

In the north-western part of the mountain glaciation occured in the high regions of Sar planina creating a big plateau glacier, covering surface of some 90-100 km^2 and projected glacial tongues forming a star. During the later period of glaciation there were only valley glaciers and the longest of them were situated in the valley of Brodska river (8 km), in the valley of Restelica river (7 km) and there is a lateral hanging glacier in Celepinska valley (5 km). The following objects have been suggested for protection as objects of geological heritage:

– the peak of Ljuboten and Ropot cirque;

– Livadicki cirque and Livadicko lake;

– the cirque in the spring of Durlov potok;

– the composite cirque by Jazinacka lakes and Virovi cirque;

– glacial series in the spring of Bukoravacka river (Prizrenska Bistrica);

– the cirque in carbonates of Kobilica;

– the double cirque Kotao in the spring of Duska river;

– Severna Rudoka cirque;

– Severna Mala Vraca cirque.

The carbonate pyramide of Ljuboten, with gigantic scree deposits, is an exquisite phenomenon in itself. The cirque in Ropotski potok, discovered by CVIJIC during his research in 1890, was the first example of glacial relief found in the Balkans. Livadicki cirque, under the Livadicki peak, in the spring area of Kaludjerska river, situated at the height of 2170 m, sized 220 x 120 m, surrounds Livadicko lake like a theatre. It is an example of perfectly preserved, school-specimen of glacial relief in shale. During the last glacial period the spring of the Durlov potok was transformed into a cirque. Relatively short river flow is descending in cascades over the series of gradually sloping sections. Block-moraines and a large stone-glacier inside the cirque are excellentlly preserved. Jazinacki cirque, in the spring of Suva river, is of huge dimensions, complex, and composed of 4 minor cirques, with a group of constant and periodical lakes, the largest of which is Veliko Jazinacko lake (2.180 m) with dimensions of 150 x 90 m, surrounded by older glacial moraines and younger block moraines. Jazinacki cirque with Virovi and bordering Blatesticki cirque are obvious examples of geomorphological contents diversity. Diversity and wealth of geomorphological forms and processes, fossil remains from various periods of geological past and contemporary elements concentrated in a relatively small area, reflect tumultuos geological past and intense geomorphological dynamics. Many of those processes are still going on, in front of our eyes, so that these cirques deserve to be called an open geomorphological text-book, as they give an accurate picture of wealth of geological diversity of regions with fossil glacial relief. The cirque in the spring of the Bukoravacka river hides, the highest glacial lake in our country, the Gornjeselsko lake at 2410 m, vigorous spring of Prizrenska Bistrica and exceptionaly well preserved frontal moraines above Gornje Selo at 1400 m. There are plans for establishment of geomorphological reserve in this area, containing the whole glacial series from cirques, through glacial waves, to frontal moraines. On the limestone section of Sar planina mountain crest (Kobilica peak) resistant rocks form jagged edge, whereas the cirque depression is filled with large blocks sacattered over moraine ramparts. In the spring of Duska river, flowing between Trpeznica and Celepinski peak, there is the double cirque Kotao with well preserved moraine ramparts. Cirques covered with snowfield block-moraines and ploughing blocks were formed on the north slopes of Rudoka and Mala Vraca during the latest period of glaciation, characterized by other contemporary periglacial forms.

3. – COMPLEX PROTECTION OF NATURE IN HIGH-MOUNTAIN REGIONS

Long presence of man in our high mountains, traditional seasonal cattle-breeding, inordinate and often unreasonable exploitation of woods, opening of mines and their infrastructure, and, lately, building of

gigantic tourism and sport centers, with cable railways and ski lifts, roads and numerous summer cottages are threatening nature and sensitive eco-systems, often resulting in catastrophic consequences. For this reason it is necessary to protect the nature in high mountain regions, including geomorphological traces of glacial period and flora and fauna. High mountain-ridges and cirques bottoms are lairs of numerous endemic and rare plant and animal species. Sar planina and Prokletije, which are the largest and highest mountains in our country, are the most significant centers of high-mountain endemism in the Balkans and in Europe. The greatest value is found in local endemic species growing in most inaccessible parts of these mountains as a result of long lasting geomorphological, genetic and ecological isolation and presence of very specific influences of surroundings which have directed them to take the original evolutionary course of aiming at highest level of adaptibility. Cirques of Jazinacko lake on the north side of Sar planina display high levels of complementarity of geomorphological and floristic elements. In their typical high mountain landscape featuring fossil glacial relief we find woods of endemic-relict pine (*Pinus peuce*) mix with high mountain bushes (*Rhododendron ferrugineum and Juniperus nana*) and herbaceous communities comprising endemic plants (*Potentilla doerfleri, Crocus scardicus, Soldanella dimoniei, Fritillaria graeca*, etc.), Alpine-Carpatian (*Primula minima, Geum montanum, Armeria alpina, Salix retusa*, etc.) and Arctic (*Juniperus sibirica, Cerastium lanatum, Juncus trifidus, Campanula scheuchzeri, Saxzifraga moschata, Gnaphalium supinum*, etc.). The outstanding limestone peak of Ljuboten is dominated by *Dryas octopetala* and very rare *Linaria alpina* in community *Carex laevis-Heliantemum alpestre* Horv., and local endemic *Sempervivum macedonicum* and *Dianthus scardicus* are known as the symbols of silicate crests. The high-mountain regions of Prokletije are exceptionally rich with Alpine and arctic-alpine elements which, depending on geological base, are diferentiated into species growing on silicate base (*Primula minima, Salix retusa, Saxifraga stellaris, Doronicum glaciale, Campanula alpina, Gentiana kochiana, Phyteuma confusum, Carex curvula*) and species growing on carbonate base (*Dryas octopetala, Silene acaulis, Anthyllis alpestris, Poligonum viviparum, Thlaspi rotundifolium, Saxifraga aizoides, Cerastium alpinum*). Highly developed glacial relief of the highest mountains in Yugoslavia, as well as the outstanding diversity of geologicalal/pedological base and presence of different geomorphological processes, have created a very complex mosaic structure of ecosystems, with frequent changes in small space, making Sar planina and Prokletije the mountains with the most significant centers of diversity of flora, vegetation and fauna. Combination of erosive and acumulative relief forms in cirques and numerous glacial lakes provides a habitat for many rare plant and animal species and their eco-systems. Together with fragile eco-systems of glacial lakes and peat bogs they form a system of exceptional complementarity. Generally speaking, the high mountains of Yugoslavia, especially Sar planina and Prokletije, represent one of the rare remaining oasis in Europe, displaying well preserved natural environment of fossil glacial relief in which we find original flora from various geological periods, thus adding to floristic wealth of the whole continent. What we need are adequate measures for protection and care for complementary values of the high mountains in Yugoslavia, aiming to preserve geological and genetic heritage, diversity of species and eco-systems and nature in general.

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Contributo alle conoscenze dei beni culturali naturali nel comune di Teramo

Contribution to the knowledge on the natural cultural heritage of the Teramo area

DI EUSEBIO F. (*) & MANETTA M. (**)

RIASSUNTO - Vengono di seguito descritti e segnalati alcuni beni naturali culturali situati nel territorio del comune di Teramo. L'area presa in considerazione è caratterizzata dalla presenza di affioramenti prevalentemente terrigeni, e, subordinatamente, da litotipi calcareo-marnosi. L'attuale quadro geomorfologico è condizionato sia dai litotipi affioranti che da fattori legati alla neotettonica nonché da interventi di natura antropica.

PAROLE CHIAVE: Appennino centrale, Geotopi, Litotipo, Morfosculture

ABSTRACT - In this article will be considered some of the environmental and heritage characteristics of the Teramo area. This area is characterized mainly by the terrigenous facies and marly-limestone lithotypes. Present geomorfology is determined either by the outcropping lithotypes or by anthropic factors.

KEY WORDS: Central Apennines, Geotopes, Lythotype, Morphological sculpture

1. – INTRODUZIONE

Il presente lavoro interessa una parte del territorio del comune di Teramo che, per le sue caratteristiche geologiche e geomorfologiche, può essere considerato un campione rappresentativo della fascia pedemontana dell'Abruzzo centro-settentrionale. Di seguito vengono descritti alcuni Beni Culturali di natura Geologica e Geomorfologica che presentano un interesse naturalistico, scientifico e paesaggistico con il fine di approfondire e diffondere la cultura *ambientale*, sia per quanto attiene la parte interpretativa dell' evoluzione del rilievo, che per la pianificazione territoriale. Inoltre, poiché da diversi anni nel nostro Paese, come nel resto d'Europa, si è affermata una politica più attenta all'ambiente, *la filosofia della tutela del paesaggio* è un obiettivo prioritario di tutte le Amministrazioni Centrali e Locali (ARNOLDUS *et alii*, 1995; CASTO & ZARLENGA, 1992; 1995).

I criteri di valutazione adottati basati su diversi aspetti, (FABBRI & ZARLENGA, 1996) in relazione alla diffusione delle *singolarità geologiche* nell'area studiata, tengono conto delle condizioni e rarità del bene geologico, della diversità e del valore paesaggistico o di bellezza naturale.

2. – INQUADRAMENTO GEOLOGICO E STRUTTURALE

La geologia del territorio teramano (fig. 1) compreso nel settore centro appenninico, è il risultato di una evoluzione prevalentemente mio-pliocenica, di un sistema catena-avanfossa-avampaese, con vergenza adriatica, cioè con una migrazione delle compres-

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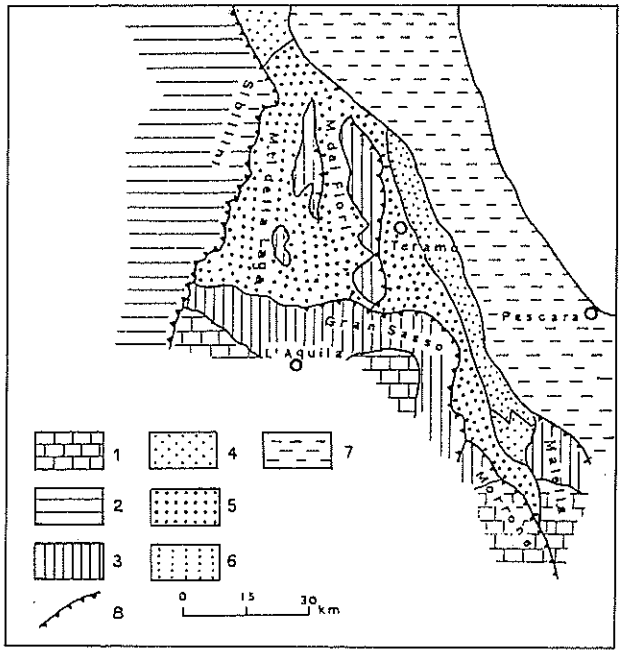

Fig. 1. – Inquadramento geologico regionale del teramano.
1) Successione calcareo-dolomitica in facies di piattaforma carbonatica (Trias superiore-Miocene medio); 2) Successione calcareo-silico-marnosa in facies pelagica (Giurassico - Miocene medio); 3) Successione calcareo marnosa e calcareo-clastica in facies di transizione prossimale (Giurassico-Miocene medio); 4) Formazione gessoso-solfifera (Miocene superiore); 5) Formazione della Laga (Messiniano); 6) Formazione Cellino (Pliocene inferiore); 7) «Argille grigio-azzurre», sabbie, arenarie e conglomerati (Pliocene medio-Pleistocene inferiore); 8) Fronti di sovrascorrimento affioranti. (Da ADAMOLI L., 1994)

– Geological schetch of Teramo area.
1) Calcareous- dolomite sequence in facies of carbonate platform (upper Trias-middle Miocene); 2) Sequence calcareous-silico-marly-pelagic facies (Jurassic-middle Miocene); 3) Sequence calcareous-marly and clastic-calcareous in proximal transition facies (Jurassic- middle Miocene); 4) Formation gessoso-solfifera (upper Miocene); 5) Laga Formation (Messiniano); 6) Cellino Formation (Pliocene); 7) Grey-blue clays, sands, sandstone and conglomerates (middle Pliocene-lower Pleistocene); 8) Outcrop of overthrust. (ADAMOLI L., 1994).

sioni dai settori occidentali verso settori più orientali adriatici.

L'evoluzione geodinamica dell'Appennino centrale, di cui il territorio teramano fa parte, è descritta e discussa in numerosi lavori dai quali è tratto il presente inquadramento schematico (ACCORDI & CARBONE, 1988; ADAMOLI, 1980, 1994; ADAMOLI *et alii*, 1991; GHISETTI & VEZZANI, 1986a; MATTEI M., 1987; PAROTTO & PRATURLON, 1975). È stata controllata dalla presenza di almeno due fondamentali unità paleogeografiche-strutturali, piattaforma carbonatica laziale-abruzzese e bacino pelagico umbro-marchigiano, che si sono impostate a partire dal Trias superiore sul margine meridionale della Tetide. Durante il Messiniano-Pliocene inferiore nell'Abruzzo teramano, in relazione alla fase compressiva ed al corrugamento appenninico, si individuarono due distinte avanfosse articolate in una serie di dorsali e di depressioni allungate longitudinalmente: il Bacino della Laga più interno e più antico ed il Bacino del Cellino più esterno. Una schematizzazione della situazione geologica dell'area può essere così descritta:

– successione di natura carbonatica, meso-cenozoica costituita da formazioni calcareo-dolomitiche, calcaree e calcareo-silico-marnose affioranti nel settore della catena del Gran Sasso e nella dorsale M. dei Fiori - M. di Campli - Montagnone;

– due diverse formazioni date da depositi terrigeni torbiditici, neogenici, che si sono deposte in due bacini adiacenti, il bacino della Laga ed il bacino del Cellino, costituite da arenarie, marne ed argille;

– depositi marini sabbioso-argillosi (fig. 2) e conglomerati del Pliocene superiore-Pleistocene che affiorano solo nella parte più orientale del territorio teramano.

L'assetto strutturale regionale è formato da tre unità tettoniche principali (ADAMOLI, 1994), geometricamente sovrapposte tra loro:

– Unità del Gran Sasso;

– Unità M. dei Fiori - M. di Campli - Montagnone;

– Unità della Laga.

La struttura di quest'ultima, che comprende quasi tutto il territorio del comune di Teramo, è caratterizzata, limitatamente ad aree circoscritte, da settori a giacitura sub-orizzontale e direzione N-S, separati da pieghe di modeste entità e da faglie. Gran parte del territorio, di contro, presenta strutture a pieghe asimmetriche coinvolte da fronti di sovrascorrimento (quest'ultimi sono in massima parte sepolti) e da faglie. Nella fascia più orientale i depositi costituiti da emipelagiti marnose, argillose e siltose presentano un andamento a monoclinale immergenti ad est.

3. – CARATTERI GEOMORFOLOGICI GENERALI

L'attuale quadro geomorfologico dell'area é il risultato di diversi fattori quali le caratteristiche lito-strutturali del substrato, l'evoluzione neotettonica, la successione degli eventi climatici quaternari e non ultima

Fig. 2. – Formazione delle emipelagiti marnose, argillose e siltose in località Villa Falchini.

– *Hemipelagic formation, clay and siltstone in Villa Falchini area.*

l'attività antropica, soprattutto quella più recente. Alle caratteristiche litostratigrafiche del substrato, costituito in prevalenza da alternanze di materiali arenacei e argillosi e in subordine da materiali calcarei, è connessa la genesi di versanti diversamente acclivi, con rotture di pendio e scarpate di erosione selettiva. In particolare appare netto il contrasto tra scarpate strutturali (orlo di scarpata con influenza strutturale) ubicate in corrispondenza degli affioramenti arenaceo-pelitici e i versanti più dolci modellati sulle argille e sulle alternanze pelitico-arenacee. Per quanto riguarda il fattore tettonico ha avuto fondamentale importanza nella morfogenesi dell'area il sollevamento generale che l'ha interessata in tempi recenti (a partire dal Pleistocene inferiore). Tale fenomeno ha indotto un generale e rapido approfondimento dell'erosione lineare sia pure con fasi di minore intensità o di stasi in relazione alle diverse condizioni climatiche che si sono avvicendate nell'area a partire dal Pleistocene medio. Ne è derivato un paesaggio caratterizzato da forte energia di rilievo e da versanti discretamente acclivi in dipendenza, come si è detto, dalle condizioni lito-strutturali del substrato. Alla successione delle diverse fasi climatiche del passato si debbono le alternanze di periodi a prevalente erosione lineare e di periodi a prevalente sedimentazione lungo le aste vallive. I depositi alluvionali che si osservano sugli attuali fondi vallivi o che appaiono terrazzati poco al di sopra di questi sono da collegare ai diffusi fenomeni di erosione sui versanti conseguenti ai massicci disboscamenti effettuati dall'uomo in epoca storica.

Più in generale si può affermare che l'attività antropica (agricoltura, urbanizzazione, estrazione degli inerti dagli alvei, regimazione delle acque etc.) ha costituito il principale fattore di controllo della morfogenesi fluviale recente ed attuale, introducendo nel quadro evolutivo dell'area processi di erosione e di accumulo notevolmente più rapidi ed intensi di quelli dovuti a cause naturali.

4. – BENI GEOLOGICI E GEOMORFOLOGICI

4.1. – Forme dovute all'azione della gravità

Le tipologie più ricorrenti nell'area sono gli scorrimenti rotazionali e planari (slides) e i colamenti (flows) (Varnes D.J., 1978). Queste frane interessano per lo più le coperture eluviali e colluviali, ma anche il substrato roccioso, per lo più di natura argilloso-sabbiosa. Le modalità con cui avvengono il distacco e la discesa delle masse dipendono da diversi fattori, tra i quali i più importanti sono la natura litologica dei materiali, il loro assetto strutturale e la morfologia del versante interessato. La zona di distacco, avvenuta la frana, si presenta di solito incavata nel versante a forma di nicchia, circondata da una scarpata (fig. 3). In località Miano è stata rilevata nel corpo di frana una «trincea» parallela al versante ed alcune contropendenze (Di Eusebio, 1987). Da segnalare diversi paesaggi calanchivi che rappresentano la forma finale un tipo di erosione «a solchi».

Fig. 3. – Frana di tipo slide in località Miano.

– *Landslide in Miano area.*

Fig. 4. – Morfoscultura su associazione arenacea in località Ponte Fosso Venacorvo S.S. 81.

– *Morphological sculpture on arenaceous formation in Ponte Fosso Venacorvo area S.S. 81.*

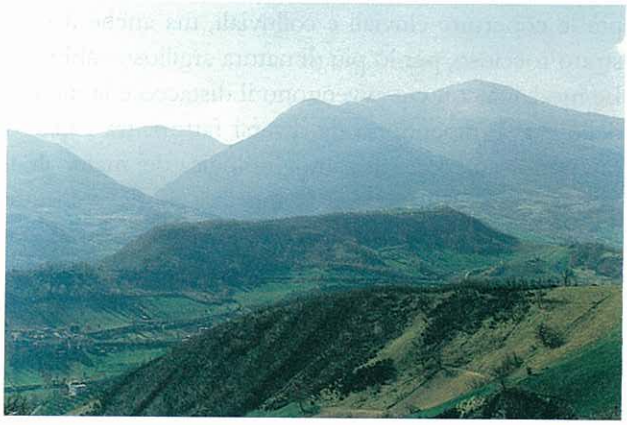

Fig. 3. – Frana di tipo slide in località Miano.

– *Landslide in Miano area.*

4.3. – Morfosculture

Il processo si innesca per il permanere dell'acqua meteorica in corrispondenza di alcuni punti di discontinuità della roccia. In questi punti meno esposti all'aria e al sole, l'acqua permane più a lungo innescando un processo di alterazione chimico-fisica. Inizia a formarsi così, con una prima desquamazione della roccia, una piccola nicchia (fig. 4). In questa, incavata e più protetta dal sole e dall'aria e quindi dall'evaporazione, si può fermare dell'altra acqua, favorendo così il procedere dell'azione erosiva, che approfondirà sempre più la cavità primitiva.

4.4. – Paleosuperfici

Anche se con un nome generico, si segnalano alcune paleosuperfici (fig. 5), (Di Eusebio, Leva & Manetta, 1996) modellatesi in un contesto morfoclimatico del tutto diverso da quello attuale. La formazione di due «generazioni» di superfici é resa possibile dal rapido sollevamento verificatosi presumibilmente tra il Pleistocene Medio e il Pleistocene Superiore: la ripresa dell'erosione dei corsi d'acqua ha consentito così lo sviluppo di valli fortemente incise, distinguendosi dalle forme più pianeggianti originatesi nel «ciclo» precedente.

5. – PROSPETTIVE FUTURE

Le aree campioni ed i beni individuati, dovrebbero essere valorizzati con la creazione di percorsi sia scientifici che didattici attraverso la creazione di sentieri, opuscoli esplicativi, utilizzo di una cartellonistica e non ultimo con il recupero di alcuni vecchi casolari adibiti all'uopo a piccoli musei.

La difficoltà maggiore potrebbe derivare nel momento in cui si voglia attuare una politica di protezione delle aree o dei beni naturali, anche se alcune Amministrazioni Locali (quelle più sensibili) negli ultimi tempi hanno preso in considerazione la possibilità di poter considerare questo programma come «lavori socialmente utili» e di conseguenza destinare alcuni giovani, che prestano questi servizi presso l'Amministrazione, ad attività che hanno come scopo quello di gestire il patrimonio geologico.

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