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Sustainable land use: How geology can contribute

Contents

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© F. Piqueiro (FotoEngenho), Entre-os-Rios village near the Douro river valley, leaned over the mouth of the river Tâmega (NW Portugal).

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Foreword

EurGeol. Vítor Correia, EFG President

"Go up on to the wall of Uruk and walk around. Inspect the foundation platform and scrutinise the brickwork. Testify that its bricks are baked bricks, And that the Seven Counsellors must have laid its foundations. One square mile is city, one square mile is orchards, one square mile is claypits, as well as the open ground of Ishtar's temple. Three square miles and the open ground comprise Uruk."
Epic of Gilgamesh, a poem from ancient Mesopotamia (circa 2100 BC).

The quotation above is from the earliest surviving great work of literature, which includes the first recorded description of urban planning. It reveals the effort of bringing together social and economical considerations in land use planning, and it highlights that the decision of where different socioeconomic activities such as agriculture, housing, industry, recreation, and commerce should take place in a territory has been made in all human societies since the Neolithic.

If land use planning is a well-known "old" process, why does it raise so many controversies today? Basically, for two main reasons: (1) huge social change happened in the 19th century, fostered by democracy, and "commoners" became entitled to have a voice (in the Western world); and (2) the world population is growing and competition for land is increasing. Of course this competition encompasses also new ideas, like wildlife conservation areas or the preservation of human heritage. Therefore, the number of stakeholders and interests involved in land use planning in the 21st century is bigger and more complex, which makes this a huge effort that troubles policy makers, because it creates protests and enemies without significant political dividends.

But it is clear we need to plan, and that land use planning is paramount to socioeconomic development. We also know that the collection and analysis of data is fundamental for informed decisions. The problem we have is that, too often, decision makers decide on land use without having detailed geological information. And because the ground is where we lay the foundations of our activities, the lack of geological information proves, on many occasions, disastrous.

The articles in this issue of the *European Geologist Journal* highlight this. Examples come from medical geology, urban engineering, agriculture, mining, groundwater management and the prevention of natural hazards. It is clear from all these articles that, quoting Hubert Wiggering, *"the gap between the knowledge available in geology and the aspired land use concepts appears to be particularly large"*[1].

To close this gap we must endeavor to provide more and better geological information to policy makers and to the public. We must also strive to inform them about the implications of this information. I trust policy makers will favour this approach, because it helps them in solving land use conflicts. And society in general recognises already that the adoption of good practices in land use planning can help achieve positive environmental, social and economical effects.

In conclusion, today (like in Mesopotamia 4,000 years ago) more and better geological information contributes to safer and more sustainable use of the natural environment, to informed public protection and to the responsible exploitation of natural resources. And all these contributions are inscribed in EFG's mission.

Vítor Cr

1 "The geology – land use – nexus". *Environmental Earth Sciences*. 2014, 71(12), pp. 5037-5044.

Managed aquifer recharge in the Marecchia alluvial fan (Rimini, Italy): trial and early results

Paolo Severi, Luciana Bonzi and Venusia Ferrari*

Among the actions designed to manage the water crisis that have taken place in the summers of recent years in the Emilia-Romagna Region (Italy) is a launched trial of managed aquifer recharge in the alluvial fan of the Marecchia River (Rimini). This test consists of conveying water through an existing channel into a quarry lake located in the recharge area of the alluvial fan. The increase in the volume of water in the lake should result in a rapid increase in the availability of water in the aquifers. Managed recharge of the aquifers can fit in the redevelopment of quarry lakes in plain areas aimed at improving the quality and quantity of groundwater bodies.

Parmi les actions projetées pour faire face à la crise (problème du déficit d'eau) qui s'est développée, ces derniers étés, en région d'Emilie-Romagne, il a été lancé un test de recharge de l'aquifère à hauteur du cône alluvial du fleuve Marecchia (Rimini). Ce test consiste à acheminer l'eau, par l'intermédiaire d'un canal, jusque dans un lac artificiel (de carrière) situé dans l'aire de recharge du cône alluvial. L'augmentation du volume d'eau au niveau du lac devrait s'accompagner d'une augmentation rapide de l'eau disponible dans les aquifères. Une gestion contrôlée de la recharge des aquifères peut concorder avec le redéveloppement des lacs de carrière en zones de plaine, destiné à améliorer la qualité et la quantité des réservoirs souterrains.

Una de las acciones diseñadas para gestionar las crisis del agua que occurieron en los veranos de los últimos años en la región de Emilia-Romagna (Italia) es un ensayo de recarga de los acuíferos en el cono de deyección del río Marecchia (Rimini). Esta prueba consiste en el transporte de agua a través de un canal existente a un lago, originado por una cantera, ubicado en el área de recarga del cono de deyección. El aumento en el volumen de agua en el lago debe dar lugar a un incremento rápido en la disponibilidad de agua en los acuíferos. La gestión de la recarga de acuíferos puede reconvertir el uso de los lagos de cantera ubicados en llanuras destinadas a mejorar la calidad y cantidad de las masas de agua subterránea.

Water resources of the alluvial fan of the Marecchia River have strategic importance for the drinking water supply of the entire Rimini area. In fact, about 28 million cubic meters of water a year are taken from aquifers of this alluvial fan, 19 of which are used for drinking water (Emilia-Romagna Region, 2005). A series of some very dry summers since 2007 has led the Emilia-Romagna Region to establish a technical committee for the management of water crises, which are particularly significant for Romagna region. The committee is coordinated by the Civil Protection and constituted by relevant technical bodies. One of the practicable actions to prevent and mitigate future water crises is managed ground-

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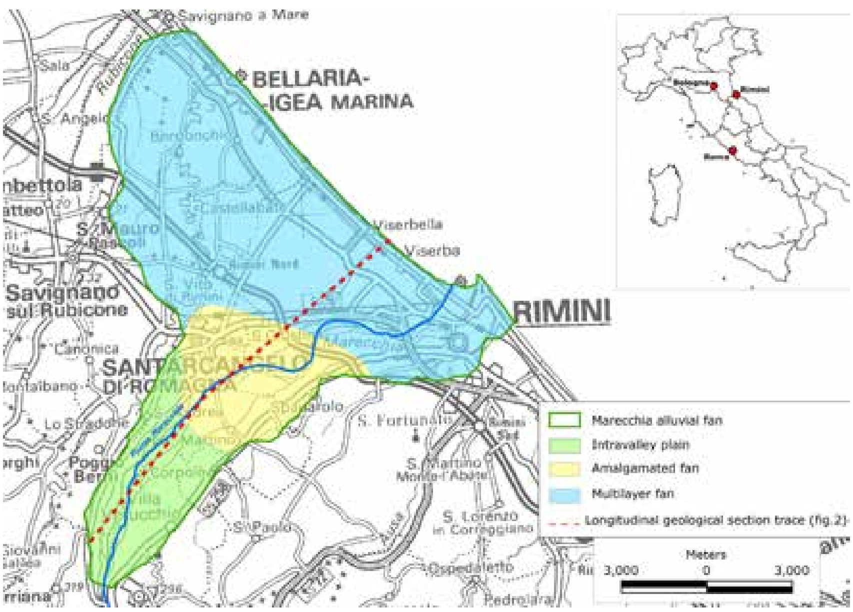

Figure 1: Marecchia River Alluvial fan and its different areas (intravalley plain, amalgamated fan, multilayer fan).

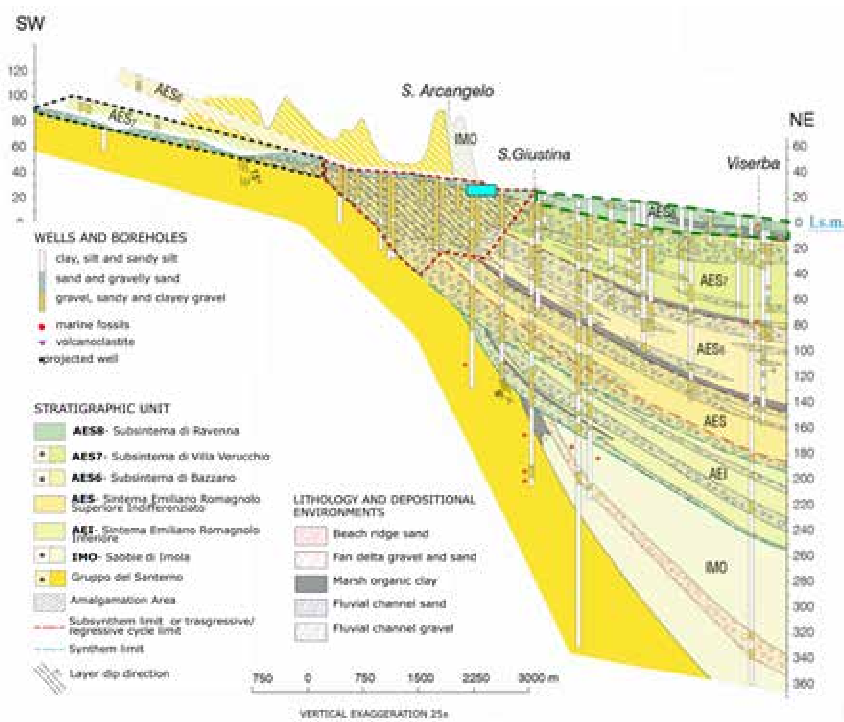

Figure 2: Longitudinal geological section of Marecchia River fan with aquifers scheme and site of the Incal System recharge lake (blue rectangle). Indication of the different areas: intramountain plain (black dashed area), amalgamated fan (red dashed area), multilayer fan (downstream) and phreatic plain aquifer (green dashed area) (from Servizio Geologico d'Italia – Regione Emilia-Romagna 2005, modified).

water recharge, which would increase the availability of groundwater. After several meetings between the various stakeholders, in January 2014 a managed recharge experiment began on the alluvial fan of the Marecchia River.

Aquifers of the alluvial fan of the Marecchia River

The Marecchia River is 70 km long and has a catchment basin of about 600 km^2; its average annual flow at the entrance of the alluvial fan is estimated at about 6 m^3 per second (Basin Authority of Marecchia - Conca, 2004).

The Marecchia alluvial fan (***Fig. 1***) develops at the end of a mountain basin and it is divided, from a geological point of view, into three different areas: an intramountain plain, formed by a thickness of not more than 10 m of mostly gravel deposits directly flat on the marine substrate; an amalgamated fan, also comprised of prevailing gravels, for a maximum thickness of up to 80 m above the sea clays; and a multilayer fan, formed by alternating gravelly levels and mainly fine levels, for thicknesses up to 250 m and more, above the coastal marine deposits of the Imola Sands (Severi *et al.*, 2014; Geological Survey of Italy - Emilia-Romagna Region, 2005; Emilia-Romagna & ENI-AGIP, 1998).

From the hydrogeological point of view, the intramountain plain corresponds to a phreatic aquifer, as well as the amalgamated fan, although there can be local confinement conditions inside it. The amalgamated portion corresponds to the area of maximum recharge of the entire fan, which is mainly due to effective infiltration of rainwater and dispersion from the Marecchia River. The multilayer fan is formed by a system of superimposed confined and semi-confined aquifers. Above them, in direct contact with the surface, there is a phreatic aquifer about 10 meters thick, mainly made of sandy silt deposits (***Fig. 2***).

The piezometric level of the Marecchia alluvial fan is constantly monitored thanks to a network of more than 70 measuring points, managed by the province of Rimini and existing since 2001. ***Figure 3*** shows the average piezometric surface of the aquifer called A1, for a period between 2001 and the spring of 2012 (Severi *et al.*, 2014). The groundwater level is between a maximum of 91 m m.s.l. and a minimum of 1 m m.s.l.. The piezometric gradient, rather high in the intramountain plain area, decreases proceeding towards the distal portion of the fan. In the area of Santarcangelo we clearly see the recharge of the river and its hydraulic connection with the phreatic aquifer of the amalgamated fan, which ends near the A14 highway, where the fan becomes multilayered and A1 aquifer is confined.

The flow direction the intramountain area is basically constant towards the north-northeast direction, except for the draining of the river, not visible in the figure for reasons of scale. Even in the amalgamated fan the flow direction is towards the north-northeast, while in the multi-layered alluvial fan, the situation is more complex: in the northern portion the flow is towards east- northeast and this is most likely due to the recharge coming from the Rubicone and Uso Rivers; in the area between the A14 Highway and the coast the flow direction

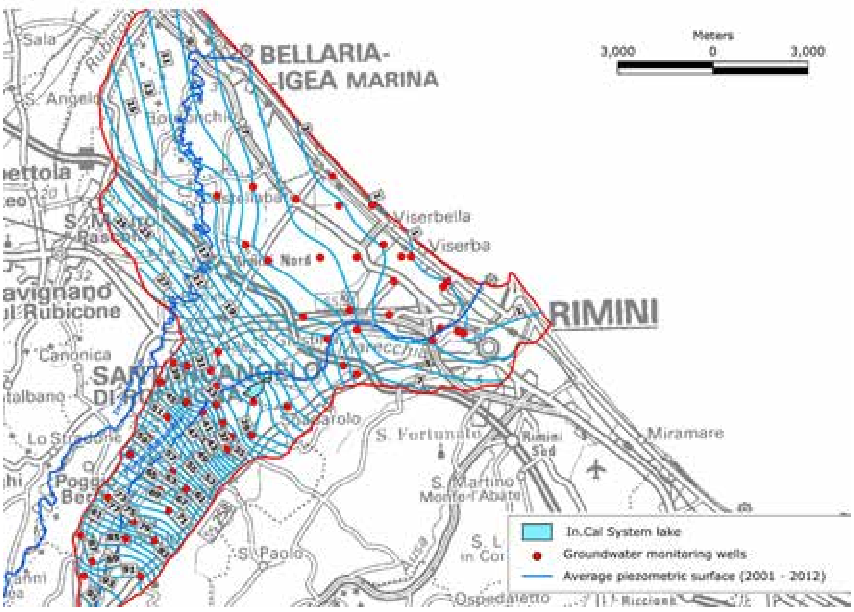

Figure 3: Average piezometric surface of the Marecchia fan (2001-2012).

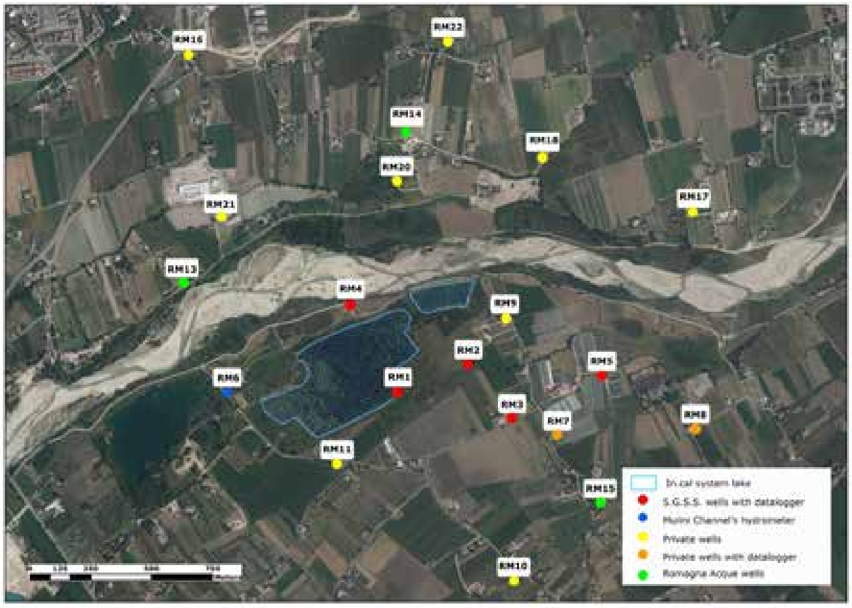

Figure 4: Monitoring network to verify the managed aquifer recharge efficacy.

is northeast with some variations, probably due to water withdrawals.

Managed recharge of the fan

In the portion of the amalgamated fan, on the right bank of the Marecchia, there are three lakes, remaining from previous quarrying activities, whose water level corresponds to the phreatic water table. These lakes are located in the maximum recharge area and so they are hydraulically connected with the entire alluvial fan. The possibility of using these lakes for managed recharge of the alluvial fan was proposed several years ago (Rimini District, 1992; Giulietti, 1993; Emilia-Romagna Region, Municipality of Rimini, Municipality of Santarcangelo, 2004), and more recently it was the subject of a further specific study designed to assess the efficacy of an intervention of managed recharge through a flow mathematical model (ARPA Emilia-Romagna, 2008).

The ongoing trial, taking into account previous studies, provides a certain amount of water to be added to the quarry lake called Incal System, which has an area of 15 hectares and is owned by the municipality of Rimini (***Fig. 3***), through the consortium Mulini Channel (whose use is leased to the Land Reclamation Consortium of Romagna). The channel takes water directly from the river, runs parallel to it for about 9 km, and finally reaches the lake, located in the recharge area of the fan, where the aquifer is amalgamated and outcropping. Under these conditions, an increase in the volume of water in the lake should be translated quickly into an increase in the groundwater level of the aquifer, meaning higher availability of water in the subsoil.

To verify the efficacy of the recharge operation, implemented a special monitoring network (***Fig. 4***) was implemented, made up of 20 measuring points, including 5 wells drilled specifically. In 9 of these points a data logger was installed for continuous monitoring of the level, temperature and specific electric conductivity at 20 °C. A data logger only for the level was also positioned in the channel through which the water flows to the lake.

Water began to enter the lake from the channel on 25 February 2014, after about a month of measuring the water table level without recharge to better assess the expected increase following the increase in the volume of water in the lake.

First results

The monitoring data collected in the period from January to April 2014 are illustrated and commented on below.

Figure 5 shows the water level measured in the intake channel and allows us to view the points at which water was flowing to recharge the lake and those at which, for various reasons, the recharge was interrupted. As we see, in fact, from 25 February to 30 April 2014 the inflow of water to the lake was not continuous; for example, the recharge was stopped from 5 to 11 March due to bad weather and from 28 March to 15 April because an excessive rise in the lake level had led to the risk of flooding the adjacent bicycle path and to compromising the ecosystems depending on the lake. Within the surroundings of the lake there are some protected bird species of Community interest, which require a precise environmental balance for nesting and survival.

Thanks to the collaboration with ARPA Emilia-Romagna some flow measurements of the Mulini Channel have been carried out and it was thus possible to draw up a flow scale for calculation of the total volume of water entering the lake, which was approximately 600,000 m^3.

Figure 6 shows the trend of groundwater level continuous monitoring in the wells closest to the lake. As can be seen from the graphs, in these points there is a direct and very clear relationship between the start of recharge and the increase in the groundwater level and between subsequent closing

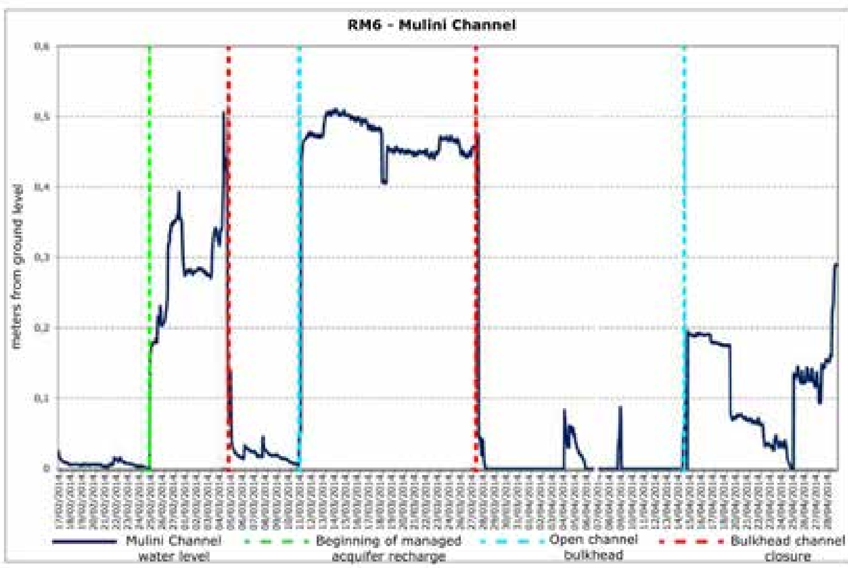

Figure 5: Water level of the channel bringing water to the lake.

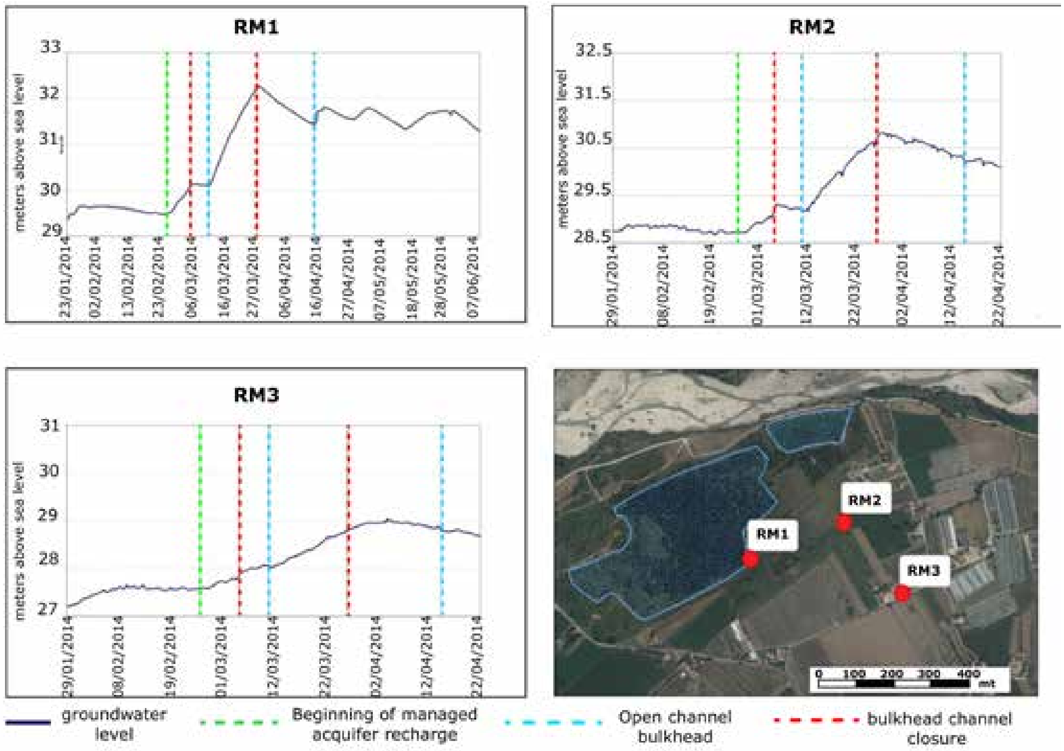

Figure 6: Piezometric level trends at three points near the recharge lake.

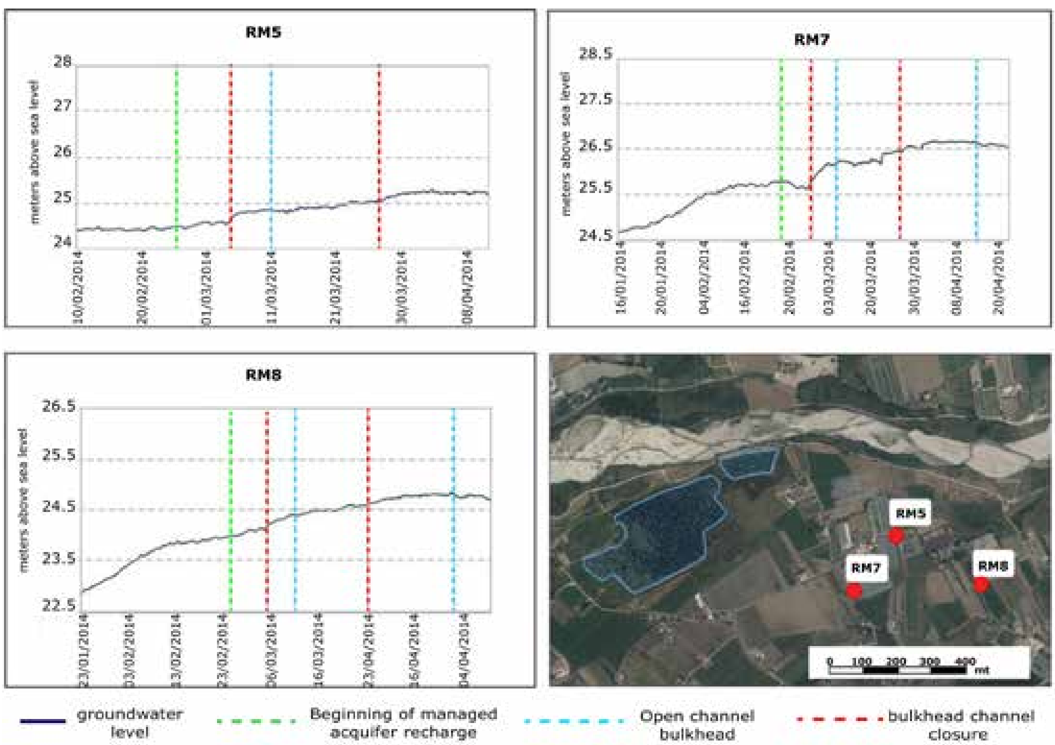

Figure 7: Piezometric level trends at 3 points far away from the recharge lake.

interventions and lower levels.

For the piezometers RM1 (located a few metres from the lake) and RM2 (200 m from the lake), the response is more immediate and evident. At point RM3 (located 470 m from the lake) there is the same relationship, but with more delayed response times and a more modest level of increase.

Figure 7 shows the trends in groundwater level in the most distant points from the lake (from 700 to 1,250 m from the lake). Also in this case it is possible to see an increase in the level, but it is less clearly correlated with recharge through the lake.

The maximum rise measured was 2.75 m by piezometer RM1, located a few metres from the lake, while the minimum elevation (0.8 m) was observed from piezometer RM5, at 800 m from the lake. The maximum elevation values were recorded between the end of March for wells closest to the lake

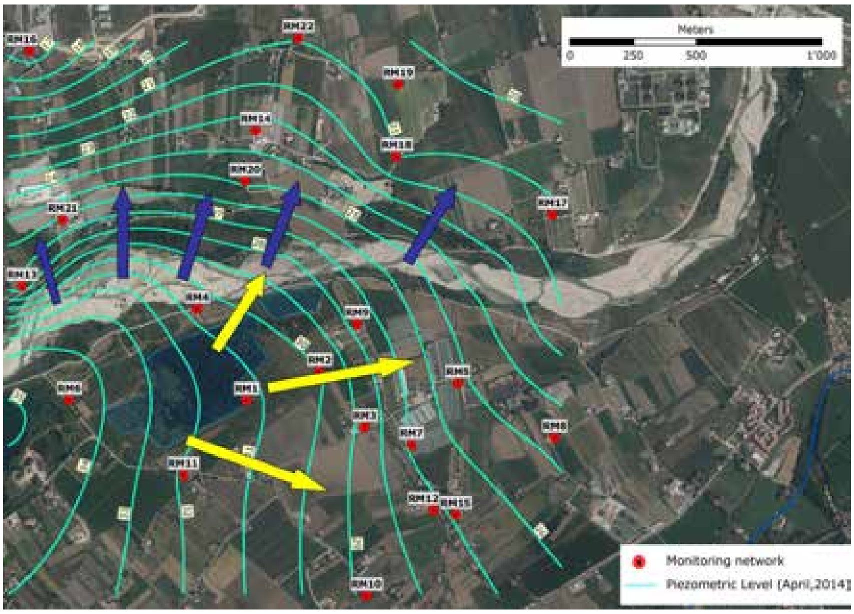

Figure 8: Piezometry near the recharge lake in April 2014. Yellow arrows show the flow from the lake to the alluvial fan, blue arrows show the flow toward the Marecchia River and the north side of the alluvial fan.

and the beginning of April for those further away. Since the intervention of recharging took place between winter and spring, the increased level observed is certainly due both to the normal aquifer dynamics during this time of the year and to the managed recharge.

As mentioned, the maximum increase in the groundwater level was 2.75 m, recorded at the RM1 point. Considering that this point is just a few metres from the lake and that here the subsoil consists of very permeable sediments (gravels are prevalent), it is likely that this increase in the level may correspond with the raising of the lake level. The surface of the lake is about 150,000 m^2, and thus the maximum increase in the lake water volume was about 410,000 m^3 which, of course, also reflects the contribution to the recharge of rainfall and the dynamics between the lake, the river and the aquifer.

The action carried out by recharging the lake is also evident from the interpretation of piezometric data detected in April 2014: the water spreads from the lake to the east, southeast and northeast, recharging the fan and partly the Marecchia River (***Fig. 8***). In order to prevent the water recharging the fan from being partially drained from the river, it will be necessary to modulate the flow rates so as to maintain the level of the lake at an appropriate altitude. However, it should be considered that during the experiment described here an important field of wells located about one kilometre from the lake (RM15 in ***Figs. 4 and 8***), was not active; its operation could certainly change the directions of groundwater flow, potentially retrieving water from the recharge lake. Therefore it will be necessary, in the near future, to carry out some checks also in this sense, in order to make the aquifer recharge most efficient.

Conclusions

The managed recharge of the Marecchia alluvial fan through the Incal System Lake (site of a former quarry) produced the expected effects: an increase in the volume of water in the lake indeed induced a rise in the water table; the increase is at its maximum close to the lake and decreases moving away from it. Part of the water that infiltrates through the lake flows also to the river. The high rise in the water level in the lake, if not properly calibrated, could create problems for the nesting and survival of some species of birds in the area. Recharging should be modulated so that no damage is done to the ecology of the area. To do this it is necessary to know the actual volumes at stake, through the most precise measurements possible of levels in the lake and river and of the flow through the channel. Thanks to the collaboration of the ARPA Emilia-Romagna Region the outflow scale of the final part of the channel was determined for calculation of the total volume of water entering the lake, which was approximately 600,000 m^3. In the near future it will be interesting to assess the influence of the nearby well field on the trends of flow lines and the possible retrieval of water from the lake. Finally, the adopted managed aquifer recharge could be considered as a sort of quarry restoration, and may serve as an example for other regions with similar needs.

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Sustainable exploitation of mineral resources within an area of the Natura 2000 network

Jorge M. F. Carvalho, João Meira, Célia Marques, Susana Machado, Lia M. Mergulhão and Jorge Cancela*

Codaçal is the name of a relatively small exploitation cluster for ornamental limestones occupying an area of 98 ha in a Natura 2000 Network protected area located in Portugal. Supported by comprehensive geological, mining and environmental studies, a land use planning methodology was developed in order to address the compatibility between the longterm sustainability of this industry with the preservation of existing protected natural values. The obtained results allow the Codaçal mineral resources to be included in the municipal land use plan.

Codaçal est le nom d'un relativement petit centre d'exploitation de calcaires ornementales occupant une superficie de 98 ha dans une zone protégée du réseau Natura 2000 situé au Portugal. Appuyé sur données géologiques, minières et environnementales, une méthodologie de planification de l'utilisation du territoire a été développée afin de répondre à la compatibilité entre la viabilité à long terme de cette industrie avec la préservation des valeurs naturelles. Les résultats obtenus constituent le support principal pour l'inclusion des ressources minérales de Codaçal dans l'aménagement du territoire au niveau municipal.

Codaçal es el nombre de una explotación relativamente pequeño de calizas ornamentales que ocupan una superficie de 98 hectáreas en un área protegido de la red Natura 2000 en Portugal. Apoyado por estudios geológicos, de minería y del medio ambiente, se ha desarrollado una metodología de planificación del uso del suelo con el fin de abordar la compatibilidad entre la sostenibilidad a largo plazo de esta industria con la preservación de los valores existentes de la protección de la naturaleza. Los resultados obtenidos permiten que los recursos minerales Codaçal se incluyan en el plan municipal sobre el uso de los terrenos.

In very simple terms, mineral resources are geological bodies that have the potential to be economically exploited. They were and still are crucial to meet the supply needs of human society, being essential to key socio-economic sectors such as construction, information technology, and the automotive and aerospace industries. Recycling, substitution and reuse are flagships for efficient use of mineral resources but they alone cannot fulfil the present and future societal demand (e.g. Espinoza, 2012; Reck & Graedel, 2012; Steinbach & Wellmer, 2010; UNEP, 2013).

The exploitation of mineral resources can only take place where they occur and their long-term availability and exploitation depends on geological, technological and market conditions, but also on the constraints imposed by land use policies and practices. In most developed countries, where there is an increasing competition for land use, the access to mineral resources is an issue that recently started to be addressed. In the European Union it was formally identified in 2008 as one of the main constraints to the security of supply of mineral products (COM(2008) 699 final, 2008).

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In Portugal, mineral resources have not received proper attention from national authorities and were usually regarded as unwanted by local political powers, despite their importance for the economy and social development and the long mining tradition. Mineral resources have often been overlooked in land use plans, thus limiting their access by the mining industry and hindering the future exploitation of valuable materials. The implementation of the Natura 2000 Network resulted in increased exclusion of mineral resources despite recommendations for the undertaking of mining activities in environmental protected areas (European Commission & Directorate-General for the Environment, 2010). However, in more recent years, concerted efforts by the Portuguese Geological Survey, the mining authority and the industry have allowed the implementation of several good practices leading to the integration of mineral resources in land use planning policies and tools.

This paper aims to present an example of such good practice in a Natura 2000 Network area where limestones are being exploited for ornamental uses, seeking the minimisation of conflict between the mining activity and nature conservation. In this regard, the competent authority for the management of the Natura 2000 Network area and an industrial association representative of the mining stakeholders worked together in a project aimed at the conciliation of exploitation activities in the protected area through improvement in their economic and environmental performance. That project, funded by European Structural Funds and by the mining stakeholders, was aimed at:

- defining strategies for the sustainable development of the extractive industry in the protected area;
- creating the geological and environmental background information for land use planning of the areas subjected to mining activity, and for the implementation of joint exploitation projects in each area;

- characterising and monitoring the hydrogeological conditions within the protected areas, evaluating their vulnerability to the extractive industry;
- inventorying, characterising and presenting a proposal for the management of the geological heritage within the protected area, in view of its association with ornamental stones as identity brands of the region;
- developing a Communication and Public Awareness Program to demonstrate the harmonisation between the extractive activity and nature conservation;
- defining a panel of sustainable development indicators for the mining activity within the protected area.

The mining industry and the Natural Park of Serras de Aire e Candeeiros

In the central region of the Portuguese territory an uplifted limestone massive stands out from the surrounding landscape. As a result of the combination of lithology with tectonic uplift, this region presents a peculiar karstic landscape with several relevant surface and underground morphological structures, as well as a large number of associated habitats with endemic flora and fauna. Besides these natural values, the region is characterised by population settlements in small villages and a few industrial activities, including tanning, livestock farming and quarrying. These activities were considered as major threats to the conservation of natural values and for this reason the region was designated as a natural park in 1979: the Portuguese Natural Park of Serras de Aire e Candeeiros (NPSAC), with an area of 389 km^2; which has also been a Site of Community Importance (SCI) of the Natura 2000 Network since 2000 (Ref. PTCON0015).

This natural park is located in the Lusitanian Basin (Pinheiro *et al.*, 1996; Ribeiro *et al.*, 1990; Wilson *et al.*, 1989) where several litho-stratigraphic sections of Jurassic formations outcrop in extensive areas (***Figure 1***). The sections of Middle Jurassic age mainly consist of light cream-coloured limestones formed under very specific palaeoenvironmental conditions, leading to their occurrence as massive limestone bodies (Azerêdo, 1998). These are exploited as 2 m^3 to 6 m^3 blocks for ornamental/high-value applications in about 100 open pits in NPSAC (Carvalho, 2012). Each one of these quarries has its own owner because in Portugal limestones are classified as a raw material of private domain. They are not dispersed; instead, they are clustered in five main exploitation areas of suitable stone quality.

Quarrying in NPSAC is one of the fundamental economic activities with local and regional impact, supporting one thousand direct jobs and generating wealth of over €100 million. Ornamental limestones exploited and transformed here are exported all over the world, having a significant contribution in the national trade balance of non-energetic raw materials. The region has a long mining tradition, preceding its designation as a Portuguese Natural Park and a Natura 2000 Network site. Indeed, the most outstanding monuments in the vicinity of the Natural Park were built with stones from this region. This is the case of the Alcobaça Monastery (12th-14th centuries), the Batalha Monastery (1386–1517) and the more recent basilicas of Fátima (1953 and 2007). Nevertheless, the mining activity for ornamental limestones only recorded considerable development after the mid-1980s in response to increasing demand from the domestic and European construction sector, supported by new technological developments and new forms of funding. A greater and more intensive development took place after 2000 as a response to market demands from China.

In 1988, with the implementation of the first land use plan for NPSAC, several conflicts arose between the mining industry and the policy guidelines and rules for environmental protection and nature conservation. In recent years, the mining activity in this region went through several difficulties due to the loss of licensed areas and the lack of alternatives in areas assigned for this type of activity by the territorial manage-

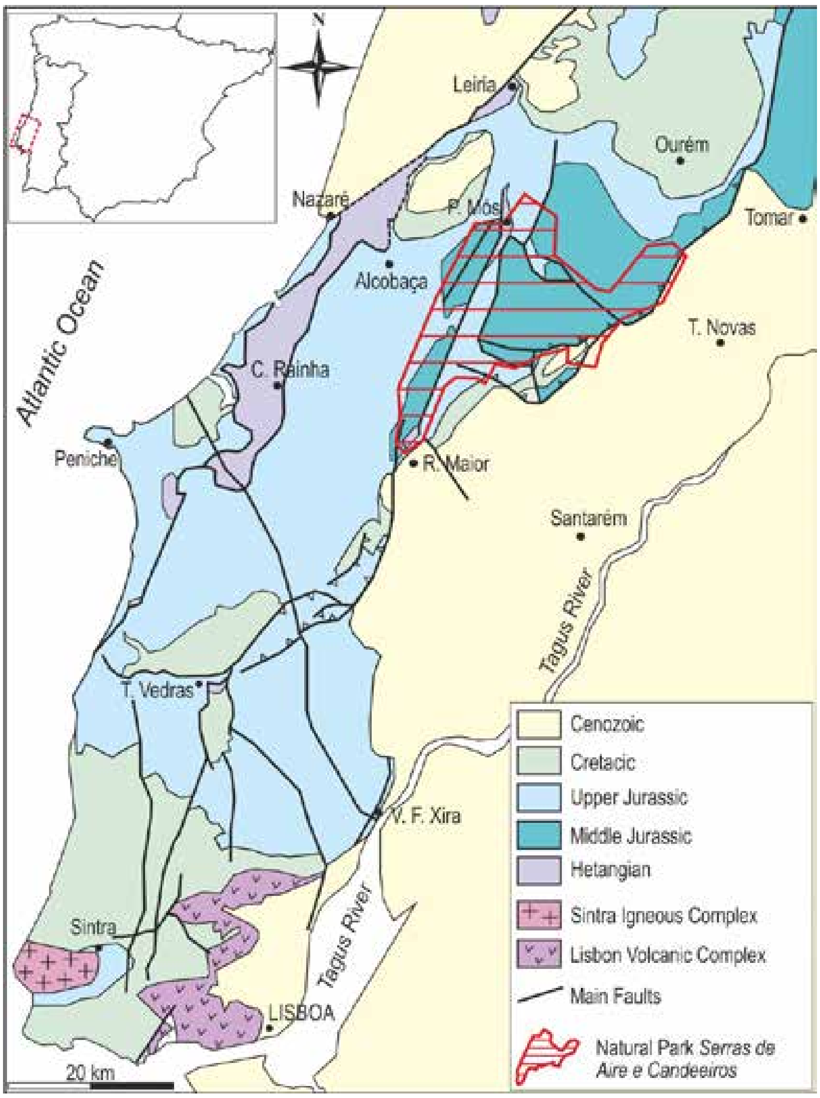

Figure 1: Geological setting of NPSAC in the Lusitanian Basin (adapted from the Portuguese Geological Map, 1:1,000,000, edited by LNEG).

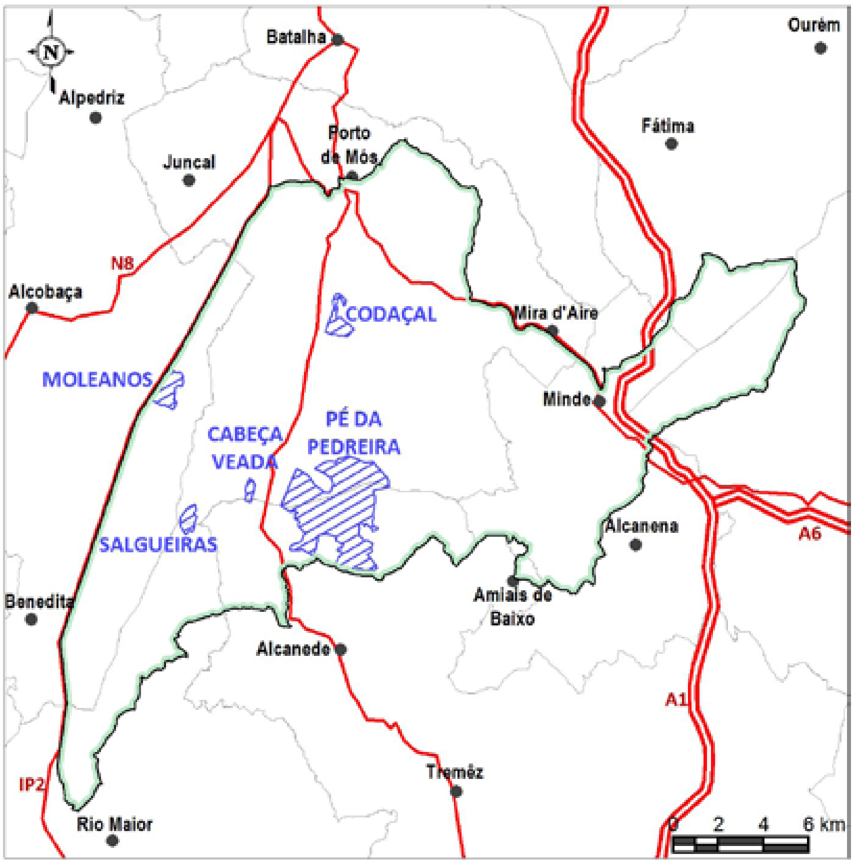

Figure 2: Geographical setting of the five sites selected as Areas of Specific Intervention related to quarrying activity within the Natural Park of Serras de Aire e Candeeiros.

ment entities. This happened because the rules and guidelines did not envisage how to harmonise the development needs of the mining activities with the nature conservation policy.

In 2010, a new land use plan and respective regulatory framework was implemented for the NPSAC. Recognising the social and economic importance of the extractive activity within the Natural Park, this new management plan established the general rules for the mining industry aiming at its compatibility with environmental protection and valorisation of natural resources. In view of those policy guidelines, a set of five Areas of Specific Intervention (ASI) for the quarrying development of ornamental stones were defined at the regional level in the new Natural Park Land Use Plan (***Figure 2***). These areas correspond directly to the main exploitation areas existing in NPSAC, occupying a total of 17.11 km^2 and representing just 4% of the NPSAC area.

Methodology and results

According to the legal Portuguese land management framework, the aforementioned ASIs should be subjected to detailed land use planning at the municipal level aimed at the establishment of compatibility measures between rational mining activity, the environmental restoration of degraded areas and the conservation of existing natural values.

Taking into account these objectives, the adopted methodology for the land use planning of each ASI was based on comprehensive geological, mining and environmental studies. These were thought to support not only land use planning but also the reorganisation of the extractive activity within each ASI, for the responsible exploitation of ornamental limestones with the best mining practices.

To achieve these intents, the first working phase consisted of the acquisition of geological, mining and environmental data for characterisation and diagnostics. In the proposed land use planning objectives emphasis was put on: 1) information to be gathered about the ornamental capability of limestones within each ASI; 2) existing quarries and environmental recovered areas; 3) flora; 4) fauna and habitats; and 5) geological and other cultural heritage sites.

The geological and biological studies were carried out at a 1:2,000 scale, as legally required for this type of land use planning map. The geological studies comprised:

- thematic geological mapping oriented to ornamental limestones;
- fracturing studies;
- hydrogeological studies;
- diamond drilling.

The obtained results allowed spatial delimitation of lithological units suitable for ornamental purposes, 3D geological modelling of the mineral deposit hosted in those units, and an assessment of resources and reserves. The hydrogeological studies allowed the delimitation of areas of vulnerability and sensitivity within each ASI.

The biological studies, supported by existing NPSAC regional data, consisted of:

- characterisation and mapping of vegetation units, giving particular emphasis to the survey of flora species more relevant for conservation within the NPSAC;
- identification of fauna species;
- identification, characterisation and mapping of biotopes and habitats.

Based on the qualitative evaluation methodology used by the Portuguese entity responsible for the management of the NPSAC, natural value maps were produced for flora, fauna and habitats. They resulted from the valuation of criteria such as the occurrence of species and habitats listed in the birds and habitats directives (Directive 2009/147/EC and Directive 92/43/EEC). The relevance of each natural value in the produced maps was expressed on an ecological relevance scale, from *Low* to *Exceptional*.

The second working phase was directed to the integration of all spatial data, making use of GIS support. The main focus was the coexistence of limestones suitable for ornamental purposes and other natural assets previously valued by means of qualitative and/or quantitative criteria, as presented in ***Figure 3***.

The main intermediate results achieved through this methodology as well as the final land use planning proposal for one of the evaluated ASIs are presented in ***Figure 4***.

Final remarks and conclusions

The planning map proposal yielded for the Codaçal area – an example of what was done for all five ASIs of NPSAC – is just one step of the whole process for the inclusion of NPSAC areas hosting significant mineral resources in land use planning. Indeed, as mentioned before, that process involves the implementation of joint exploitation projects for each ASI, as well as a general

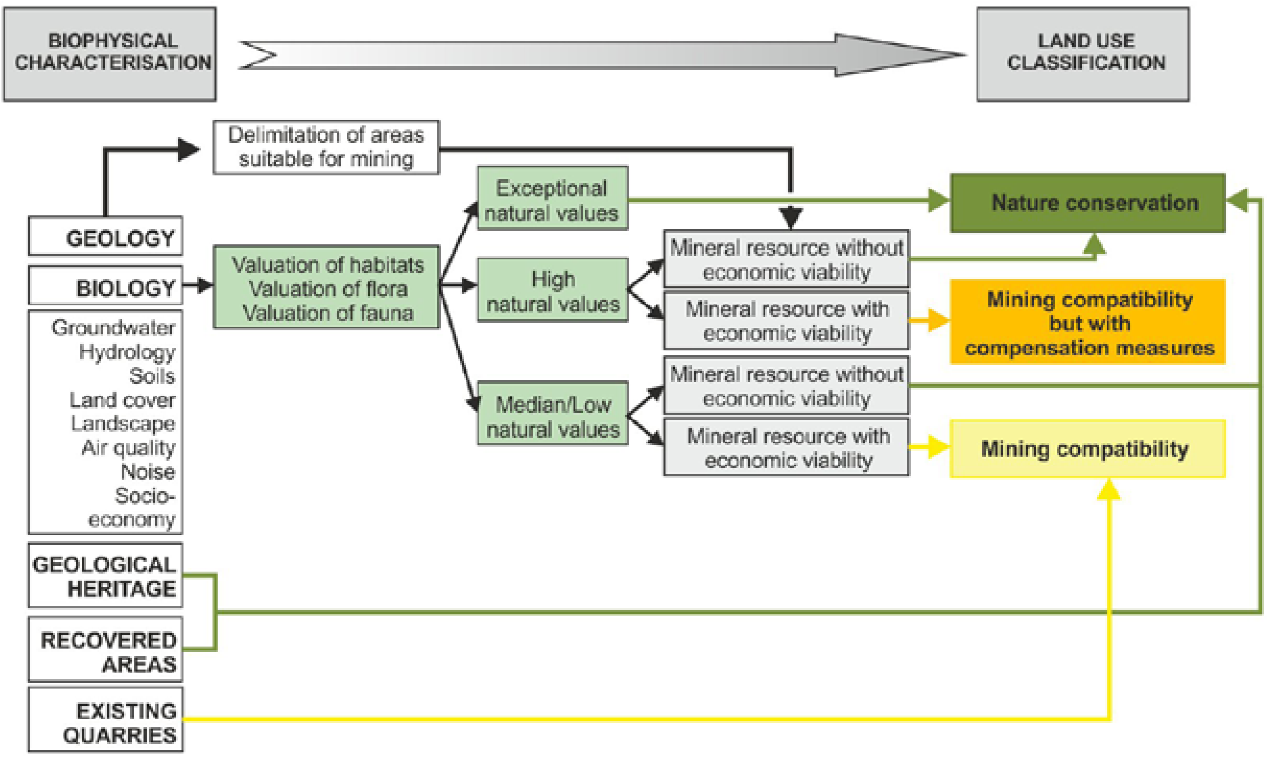

Figure 3: Methodology used for the compatibility between quarrying and nature conservation on land use planning.

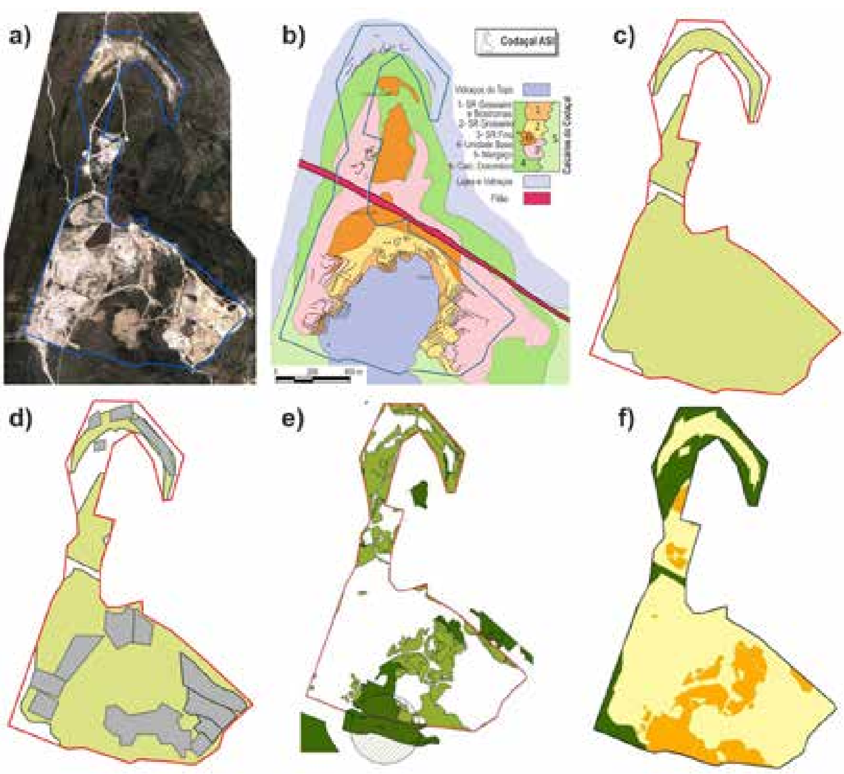

Figure 4: Main intermediate results from geological and environmental studies carried out at the Codaçal ASI: a) aerial view of the Codaçal ASI; b) geological thematic mapping; c) delimitation of the suitable areas for limestone quarrying; d) existing licensed quarries; e) GIS integration of the natural values evaluation process; and f) land use spatial planning proposal for the Codaçal ASI (colours according to Figure 3*).*

waste management plan, an environmental impact assessment and an Intervention Plan in Rural Area. This Intervention Plan is the formal Portuguese designation for the detailed land use management plans that are held at municipal level for some areas of the territory that are thought to need a particular approach. It comprises a Regulation Document, a Land Use Map at the 1:2,000 scale (where several spatial land use classes are defined), and a Map of Conditioning Factors (containing the restrictions of public utility) at the same scale.

Nevertheless, although the present land use proposal is just one step of a long process, it is extremely relevant for the whole procedure; it represents a turning point in the relationship between mining industry stakeholders and environmental protection authorities after more than 20 years of land use conflicts. Working in a collaborative way, it was possible to accomplish a balance between nature conservation and the mining industry. Furthermore, that joint proposal is also relevant because it demonstrates how crucial geological knowledge is for the suitable practice of land use planning, achieving supporting solutions that prevent the sterilisation of mineral resources (i.e., withdrawing the possibility of being exploited), thus contributing to the sustainable supply of mineral raw materials to Europe from domestic sources.

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From engineering geosciences mapping towards sustainable urban planning

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Maps are of key topical importance in urban geoscience and engineering practice, mainly in field data synthesis and communication related to a number of fields, such as geomatic techniques, applied geology and geomorphology, engineering geology, soil and rock geotechnics, slope geotechnics, subsurface site geotechnical investigations, urban hydrology, hydraulics and sanitation, coastal zones management, urban geoarcheology and heritage, planning and land use. The value of preparing engineering geoscience maps and plans specifically for urban engineering purposes are still a challenging task, particularly to end-users and planners. Nowadays, the application of Geographic Information Systems to geosciences and engineering has become more common. This paper emphasises the importance of an accurate ground field survey and inventory at several scales, GIS mapping and databases, and integrated multidisciplinary urban studies as useful tools to support a sustainable land use planning. Some selected sites are highlighted to demonstrate the importance of urban mapping for land use planning. Thus, in this study the significance of a smart urban geoscience approach is stressed.

Les cartes sont d'une importance topique clé dans la géoscience urbaine et la pratique de l'ingénierie, principalement dans la synthèse des données de terrain et de communication liées à un certain nombre de domaines, tels que: les techniques géomatiques, la géologie et géomorphologie appliquées, la géologie de l'ingénieur, la géotechnique des sols et roches, la géotechnique de stabilité des pentes, les investigations géotechniques du sous-sol, l'hydrologie urbaine, l'hydraulique et de l'assainissement, la gestion des zones côtières, l'archéologie urbaine et du patrimoine, la planification et l'utilisation des terres. L'utilité des cartes et des plans géoscientifiques à des fins d'ingénierie urbaine demeure relative, en particulier pour les simples utilisateurs et pour les planificateurs. De nos jours, l'application de systèmes d'information géographique aux géosciences et à l'ingénierie est devenue plus courante. Cet article met l'accent sur l'importance d'une étude de terrain rigoureuse et d'un inventaire à plusieurs échelles, d'une cartographie SIG et de bases de données; la valeur des études urbaines multidisciplinaires intégrées en tant qu'outils utiles pour soutenir une planification de l'utilisation durable des terres est mise en avant. Certains sites sélectionnés sont mis en évidence pour démontrer l'importance de la cartographie urbaine dans la planification de l'utilisation des terres. Ainsi, dans cette étude, l'importance du concept de géosciences urbaines soutenues par une technologie intelligente est soulignée.

Los mapas son de importancia clave en geociencias urbanas y en la práctica de la ingeniería, principalmente en la síntesis de datos de campo y en la comunicación relacionada con una serie de campos, tales como: técnicas geomaticas, geología y geomorfología aplicadas, ingeniería geológica, geotecnia de suelos y rocas, geotecnia de laderas, investigaciones geotécnicas del subsuelo, hidrología urbana, hidráulica y saneamiento, gestión de zonas costeras, geoarqueología urbana y patrimonial, planificación y uso de la tierra. La elaboración de mapas y planos de ingeniería de ciencias de la Tierra, específicamente para utilización en ingeniería urbana, sigue siendo un reto difícil, especialmente para los usuarios finales y los planificadores. Actualmente, es de uso común la aplicación de los Sistemas de Información Geográfica a las ciencias de la tierra e ingeniería. Este documento enfatiza la importancia de un adecuado estudio de campo y de un inventario a varias escalas, cartografía GIS y bases de datos y estudios urbanos multidisciplinares, integrados como herramientas útiles para apoyar una ordenación sostenible del territorio. Algunos lugares seleccionados se presentan para demostrar la importancia de la cartografía urbana en la planificación del uso de la tierra. En este estudio se destaca la importancia del enfoque de las geociencias en medio urbano, apoyadas con tecnología inteligente.

Mapping, engineering geosciences, planning

These thoughts from Dearman and Fookes (1974) are still topical: *"Undoubtedly the biggest development required in the field of engineering geological mapping is in bridging the apparent gap between the suppliers of the expertise on the one hand and the users of the service on the other"* (p. 252). A range of best practices in the preparation of applied geological maps or plans for engineering purposes have been highlighted throughout several key publications in the last half-century (e.g., Dearman and Fookes, 1974; Varnes, 1974; Matula, 1979; Dearman, 1991; Smith and Ellison 1999; Griffiths, 2001, 2002; Dobbs *et al.*, 2012; and references therein). Engineering geological maps or plans are a resourceful database of ground information on lithology, structure, morphology, soil and rock mechanics, hydrology and ground investigation conditions, among others. The purpose of these maps or plans depends on scale, such as: i) detailed survey studies, plans and cross-sections (large-scale): 1:50 to 1:250; ii) general maps or plans (large to medium-scale): 1:1,000 to 1:10,000; iii) regional maps and planning purposes (medium to small-scale): 1:50,000

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Figure 1: Cloud diagram based on keywords about the engineering geological maps and images illustrating the use of maps in engineering geosciences practice, as well as communicating and teaching applied geosciences in the field.

to 1:200,000. The engineering geological plans or maps are particular useful for the applied geologist or engineering geologist, as well as in geological, geotechnical, civil, mining or environmental engineering practice. Engineering geological plans are produced for specific engineering purposes on a large scale either during site investigation or during the construction stage of a project (Dearman and Fookes, 1974; Griffiths, 2001). They are not intended as a replacement for detailed site-specific desk studies or ground investigations (Dobbs *et al.*, 2012).

Dearman (1991) indicated the key importance of the so-called engineering geological zoning map. This identifies areas on the map that have approximately homogenous engineering geological behaviour and conditions. Such zones would normally be derived from the factual data compiled on the base map and consequently should not form part of the original map but can be produced as an overlay (Griffiths, 2001). In addition, comprehensive and accurate engineering geological plans associated with so-called unforeseen ground conditions play an important role in supporting or rejecting some design and/or construction options. Dobbs *et al.* (2012) state they serve to raise the awareness of the impact that geology has on planning and development, and act as a reminder of the importance of engineering geology (and correlated disciplinary areas, such as hydrogeology, environmental geology, applied geomorphology, etc.) in reducing the hazards or risks associated with human interaction in the built and natural environment. In short, all geotechnical practitioners aim to contribute to the correct study of the ground behaviour of soils and rocks, its applications in sustainable design with nature and environment and to the development of society (e.g., Dearman and Fookes 1974; McHarg, 1992; Griffiths, 2002, 2014). That approach stresses particularly the key importance of field-based training in applied geoscience and engineering geology for geologists, engineers, architects and planners (Griffiths, 2014), as well as GIS-based mapping for geoengineering purposes and communication skills in applied geosciences (e.g., Chaminé *et al.*, 2013, 2014; Marker, 2015).

New developments in surveying acquisition for applied mapping (sketch or general maps, engineering geological maps and geotechnical maps, at diverse scales) take on critical importance in further stages of ground investigations and modelling. It is also important to highlight the value and cost-effectiveness of accurate mapping for geoengineering, georesources and planning purposes (Griffiths, 2002, 2014), *Figure 1*.

Urban engineering geosciences mapping in practice

Bandarin and van Oers (2015) state an important issue: *"As much as cities are a layered built construct, they rest on another layered system, the geological strata formed during Earth's history. This relationship is a fundamental one, albeit often forgotten with dire consequences for urban conservation and for the protection of urban environments from natural hazards. (…) the way in which the geological setting has determined the ways in which cities were built, their morphology, building materials and building types, as well as the way they were able to adapt to the hydrological and ecological constraints."* (p. xiv-xv).

Urban geoscience is an interdisciplinary and transdisciplinary field encompassing earth sciences, environmental sciences and socioeconomic sciences for addressing Earth-related problems in urbanised

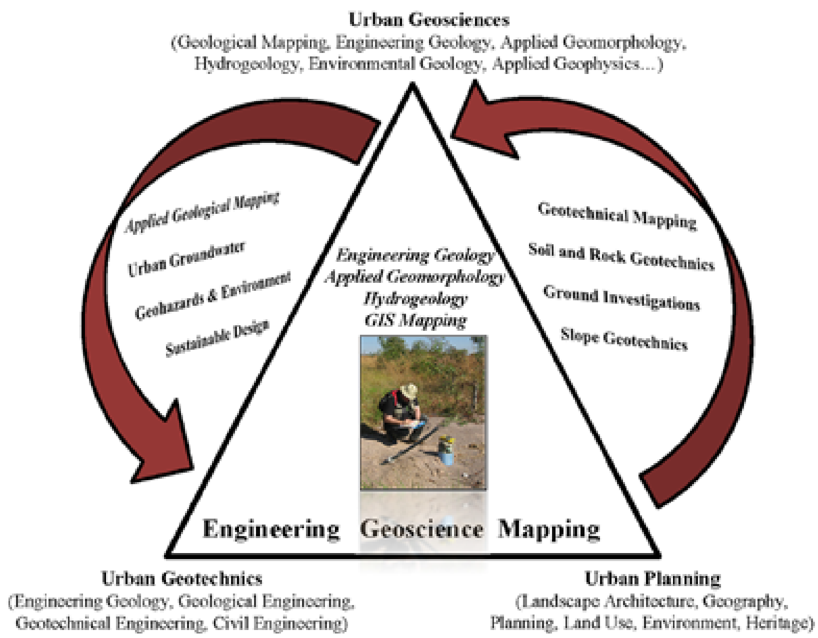

Figure 2: The main scientific and technical fields of applications of engineering geoscience mapping for urban areas related to applied geosciences, geotechnics and planning.

Table 1: Summary data for engineering geological maps and plans (revised and updated from Dearman and Fookes 1974).

GIS-based maps/plans		Key information	Typical scales	Typically prepared by	Method	Engineering use
A. Engineering Geological Maps		*GIS Mapping in terms of general geology/ geomorphology plus additional engineering information and inferences*	*1:10,000 or smaller*	*Government agencies, applied geologists, engineering geologists*	*From remote sensing and/or ground survey*	*Planning; preliminary reconnaissance; general information*
B. Engineering Geological Plans						
	i) Reconnaissance	*GIS Mapping in terms of descriptive soil or rock engineering, geostructure, applied geomorphology*	*1:500 to 1:10,000*	*Consultant engineers, site investigation specialists using engineering geologists, applied geomorphologists/ geologists, geological and geotechnical engineers*	*From remote sensing and walk-over survey*	*Detailed planning and reconnaissance*
	ii) Site investigation		*1:100 to 1:5,000*		*As above plus instrument-assisted techniques*	*Site investigation*
	iii) Construction		*1:100 to 1:1,250*		*From photogrametry, walk-over surveys plus instrument-assisted techniques*	*Ground investigations and recording during construction*
C. Geotechnical Plans						
	i) Reconnaissance	*GIS Mapping in terms of selected engineering design parameters with either geological/ geotechnical or engineering parameter boundaries*	*1:500 to 1:10,000*	*Consultant engineers, site investigation specialists using engineering geologists and applied geomorphologists/ geologists, geological and geotechnical engineers*	*From remote sensing and walk-over survey*	*Detailed planning reconnaissance*
	ii) Site investigation		*1:100 to 1:5,000*		*As above plus instrument-assisted techniques*	*Site investigation*
	iii) Construction		*1:100 to 1:1,250*		*From photogrametry, walk-over surveys plus instrument-assisted techniques*	*Ground investigations and recording during construction*
D. Research: Engineering Geological/Geotechnical Maps/ Plans		*GIS Mapping oriented to applied geology/ geomorphology research plus additional engineering information*	*1:10,000 or smaller to 1:25,000*	*Researchers: geoscientists, engineers*	*Remote sensing to field survey plus instrument-assisted techniques*	*R&D for engineering purposes oriented for the development of the new urban GIS-based mapping methodologies and techniques; wherever possible based in real case studies (site investigations) or key areas/regions, as well as in a comparative framework*

areas (e.g., see details in the multivolume from the "Atlas of Urban Geology" (United Nations) ***https://www.un.org***). Chaminé *et al.* (2014) highlight the importance of urban geoscience evolving to a holistic paradigm of smart urban geoscience, particularly related to geology, hydrology, groundwater, rock and soil geotechnics, natural resources, environment, geohazards, heritage and geoarchaeology issues. A core aspect of the smart urban geoscience concept necessarily includes Geographic Information Systems (GIS) as a tool for digital mapping and communication to a broad community. That approach includes the integration of numerous data about all features of urban areas, such as transport, environment, economy, housing, culture, science, population, health, history, architecture, heritage, etc. In addition, the format of a balanced multipurpose engineering geological map depends largely on its main purpose and the requirements of the end-users, as well as the need to communicate information to all agents involved (practitioners, researchers, stakeholders, decision makers and the public), as depicted in ***Figure 2***.

In engineering geological mapping assessment, it sounds more accurate to create a comprehensive approach, both scientific and technically and also economically (e.g., Varnes, 1974; Matula, 1979; Dearman, 1991; Griffiths, 2002, and references therein) in order to: i) acquire a rather complete set of engineering geological data; ii) field-map systematically larger areas in different scales; iii) collect the comprehensive information in special data banks; and iv) use GIS-based mapping techniques. ***Table 1*** shows the main types of engineering geological and/or geotechnical maps/plans.

There are some fundamental types of GIS-zoning maps at various scales for engineering, georesources and planning purposes (e.g., Matula, 1979; Griffiths, 2002; Chaminé *et al.*, 2013): i) maps for ground site investigations of engineering geological assessment and design geotechnical parameters, including mineral

Table 2: Basic information data to be recorded on an engineering geological map (updated from Griffiths, 2001).

Engineering geological map: basic data in a GIS-based environment and using engineering codes of practice (IAEG, ISRM, ISSMGE, GSE|GSL, AEG, IAH, ASTM, CFCFF, etc.) for description and assessments of soils, rocks and groundwater
Geological data
Mappable units (on the basis of descriptive engineering geological terms)
Geological boundaries (with accuracy indicated)
Description of soils and rocks (using engineering codes of practice)
Description of exposures (cross-referenced to field notebooks)
Description of state of weathering and alteration (notes depth and degree of weathering)
Description of rock discontinuties based on scanline surveys
Subsurface conditions (provision of subsurface information if possible, e.g. rockhead isopachytes)
Hydrogeological data
Availability of information (reference to existing maps, well logs, abstraction data, etc.)
General groundwater conditions (flow lines; piezometric conditions; water quality; artesian conditions; potability, etc.)
Hydrogeological properties of rocks and soils (aquifers, aquicludes and aquitards; permeabilities; perched water tables, etc.)
Springs and seepages (flows to be quantified wherever possible)
Hydrogeomechanical properties and behaviour
Geomorphological data
General geomorphological features (ground morphology, landforms, processes)
Ground movement features (landslides, subsidence, solifluction lobes; cambering)
Geohazards
Mass movement (extent and nature of landslides, type and frequency of landsliding, possible estimates of runout hazard)
Rock slope stability and assessement
Flooding (areas at risk, flood magnitude and frequency, coastal or river flooding)
Coastal zones (cliff form, rate of coastal retreat, coastal processes, types of coastal protection)
Seismicity (seismic hazard assessment)
Vulcanicity (volcanic hazard assessment)

and groundwater resources and hazards; ii) maps for protection and sustainable exploitation of georesources, including groundwater resources; iii) maps for municipal and/or regional planning, land development and construction; iv) maps for delimitation of endangered areas, for organising the warning systems, and for recommendation of measures against active or potential geological hazards; and v) maps for protection of vulnerable geological environments prone to undesirable changes caused by development and/or geohazards. ***Table 2*** provides a main checklist related to the basic information that should be recorded on the engineering geological map.

Concerning the communication and dissemination of geological information in urban areas planning, Marker (2015) raised several important issues: i) development should be carried out balancing social, economic and environmental impacts in planning policies and decisions supported by sustainability and environmental appraisals, site investigations and public consultations; ii) scientific and technical ability should be harmonised with social and economic data, such as geoscience data on mineral, water, soil and conservation resources; ground conditions for development; areas potentially affected by hazards; sources of emission to the air, soil and water; and potential waste management sites; iii) many participants in the planning process have limited understanding of geoscience issues; iv) diverse audiences require customised results in straightforward language with good illustrations and local examples. In addition, geoscientists, engineers, Earth-related professionals and planners should use maps and GIS because these are good means of communication, but careful explanation is necessary; v) dissemination needs early and continuing engagement with stakeholders and often needs to be repeated.

Engineering geological mapping needs to advance towards an insightful cartographic reasoning concept established on geomatic techniques, unmanned aerial vehicles (micro drones) for detailed surveys, fieldwork, engineering geosciences, Earth-based systems conceptualisation and numerical ground modelling, among others.

Selected sites: coupling engineering geoscience mapping and urban planning

A comprehensive integrated study of urban geoscience was carried out at two selected urban sites of NW Portugal (the cities of Vila Nova de Gaia and Penafiel). The study coupled GIS-based mapping with urban geotechnical and groundwater assessments, respectively. Thematic maps were prepared from multi-source geodata, namely remote sensing, morphotectonic and geological mapping, as well as geotechnical and hydrogeological field surveys. These maps were converted to GIS format and then integrated with the intention of building engineering geological maps and/or environmental hydrogeological maps that combine geohazards assessments and environmental protection groundwater resources focused at the municipal planning level. The basic techniques of mapping, engineering geosciences, applied geomorphology, and applied hydrogeology were applied at the study sites (e.g., Dearman, 1991; Griffiths, 2002; Teixeira *et al.*, 2013; Freitas *et al.*, 2014, and references

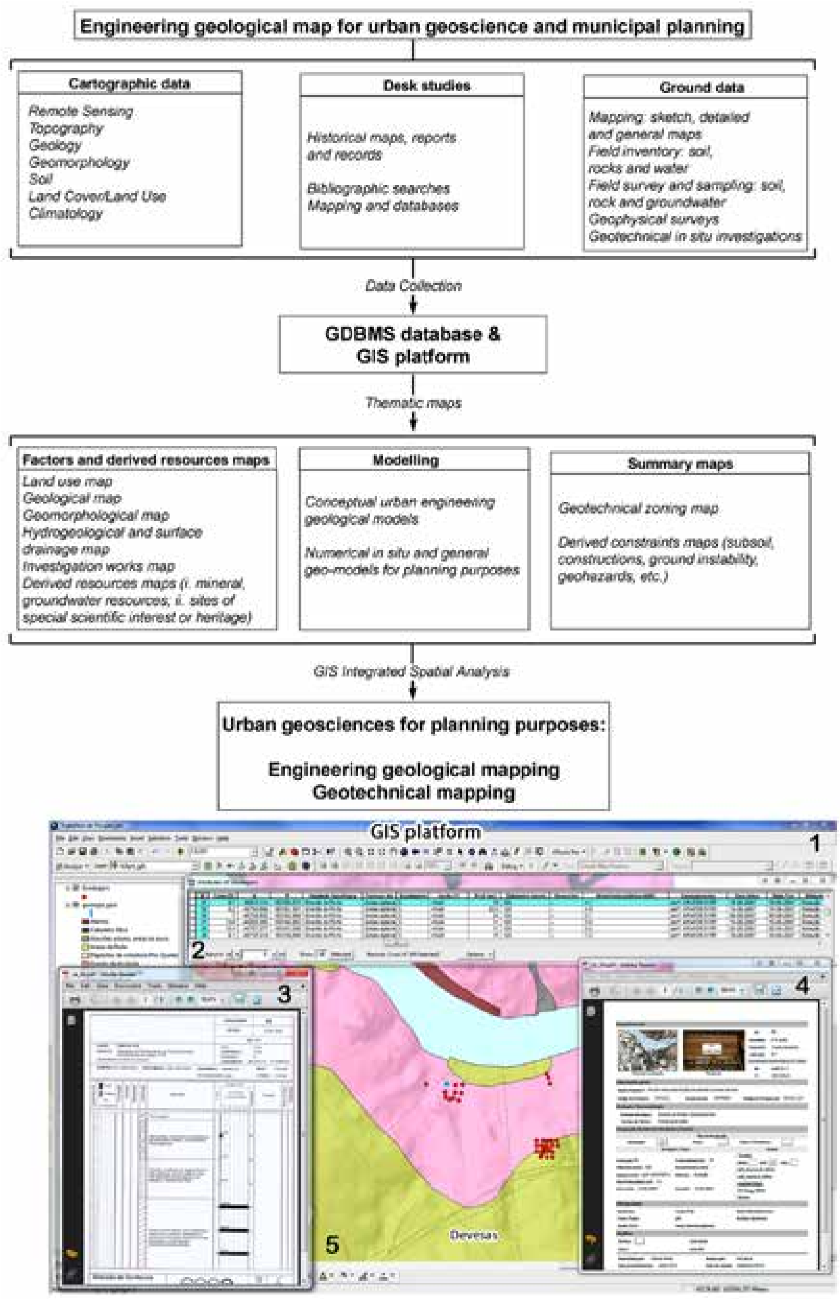

Figure 3: Conceptual flow chart of the engineering geological map for urban geoscience and municipal planning. 1. Application tool to create hyperlinks between features (line, point or polygon) and other files; 2. Database related to ground investigation information; 3. Geotechnical borehole datasheet; 4. Geotechnical inventory datasheet (field and desk data); 5. Detailed investigation works mapping with geological background information.

therein). This integrative approach allowed the basic description of rock masses and established engineering geosciences maps (using particularly the engineering codes of practice of several organisations: IAEG – International Association for Engineering Geology and the Environment (***www.iaeg.info***); GSE|GSL – Engineering Geology Group of the Geological Society of London (***www.geolsoc.org.uk***); ISRM – International Society for Rock Mechanics; ISSMGE (***www.isrm.net***) – International Society for Soil Mechanics and Geotechnical Engineering (***www.issmge.org***); CFCFF – Committee on Fracture Characterization and Fluid Flow (***www.nap.edu***)). ***Figure 3*** presents a flow chart of the engineering geological map for urban geoscience and municipal planning.

This approach deals with a holistic and systematic methodology that encompasses several layers of information obtained from diverse sources, such as field data, ground investigations, laboratory testing and historical maps, charts and/or documents. The thematic maps are developed by using all the layers and inputs. Subsequently, the information is embedded in GIS software and geodatabases. Finally, these outputs and the data analysis will support the framework of modelling issues (e.g., Oliveira *et al.*, 2009; Chaminé *et al.*, 2010; Teixeira *et al.*, 2013; Freitas *et al.*, 2014; Pires *et al.*, 2016).

Vila Nova de Gaia site

The study area highlights the importance of a geological and geotechnical urban study for a better understanding of granitic rock slopes stability in Vila Nova de Gaia's (NW Portugal) riverside downtown (particularly in the S. Félix da Marinha, S. Pedro da Afurada and Canidelo sites). In addition, there are significant historical records of rock fall activity in the region (e.g., Oliveira *et al.*, 2009; Chaminé *et al.*, 2010; and references therein). In this region typical slope failure mechanisms result in a range of failure types (e.g., plane sliding, wedge failure, partial toppling and buckling) and are dependent mainly on the rock discontinuities network, slope orientation and severity of the hydroclimatological events.

Vila Nova de Gaia is one of the largest cities in Portugal, with a continuous need for urban development and expansion. The Porto and Vila Nova de Gaia urban areas are built along the hillsides on a littoral platform characterised by a quite regular planation surface dipping gently to the West. This platform was cut by the Douro River in a steep-walled valley with sharp and high slopes that constitute the so-called riverside downtown with its typical entrenched geomorphological framework (Oliveira *et al.*, 2009; Chaminé *et al.*, 2010, 2014; Freitas *et al.*, 2014). The Vila Nova de Gaia urban area is located in a complex geotectonic framework encompassing a crystalline fissured basement of highly deformed and overthrusted Late Proterozoic/Palaeozoic metasedimentary and granitic rocks (***Figure 4***). The bedrock is mainly composed of phyllites, micaschists, gneisses and granites, while post-Miocene alluvial and Quaternary marine deposits dominate the sedimentary cover. The drainage network reflects the regional tectonic lineament systems (namely NNW–SSE, NE–SW, ENE–WSW). The hydrogeology of Vila Nova de Gaia region is mainly dominated by a diverse of groundwater units such as overlying sediments, weathered rocks, weathered–fissured zones, and fractured hard-rock crystalline substratum.

Figure 4 illustrates the general engineering geology mapping framework of the Vila Nova de Gaia riverside downtown and the main hazard rock slope instability sites for the region. The figure also presents a case study of Afurada rock slope stabilisation (details in Chaminé *et al.*, 2010).

S. Pedro da Afurada is a fishermen's picturesque parish of the Vila Nova de Gaia urban area. The Afurada rock-mass exposure is formed of medium to fine grained, two-mica sheared granite, which outcrops slightly to moderately weathered (W_2 to W_3) and locally highly weathered (W_4). The slope area is a scarp fault, trending NE-SW, limited at the top by the Afurada Church and at the base by the Douro river. The slope area showed historical records of active small to medium failures and there has been reported rock fall, with around 1m^3 granitic blocks, as well as small-scale rock fall in surrounding Douro riverside downtown (Chaminé *et al.*, 2010), ***Figure 4***. The total slope length has an extension of 187.5 m and a height that varies from 5 to 15 m above the road, oriented N85ºE. The studied slopes dip about 85° and their evolution is due to rock falls as a consequence of the jointing of the rock mass. The preliminary failure susceptibility of the rock slope was evaluated in terms of the computed SMR [Slope Mass Rating] values. For the studied slope sections, the SMR index pointed to a range of 45 to 53 with instability behaviour of III_a and III_b types, which can be classified as fair rock slopes. RMR [Rock Mass Rating] and GSI [Geological Strength Index] geomechanical values allowed the granitic slopes to be classified as poor rock masses. A stabilisation program of further works was accomplished after the geological, geotechnical and geomechanical studies, consisting mainly of the filling of the joints with grout and the systematic bolting of block masses, combined with steel reinforced mesh and, sometimes, with polymeric tridimensional geo-mesh (Chaminé *et al.*, 2010; and references therein), ***Figure 4***.

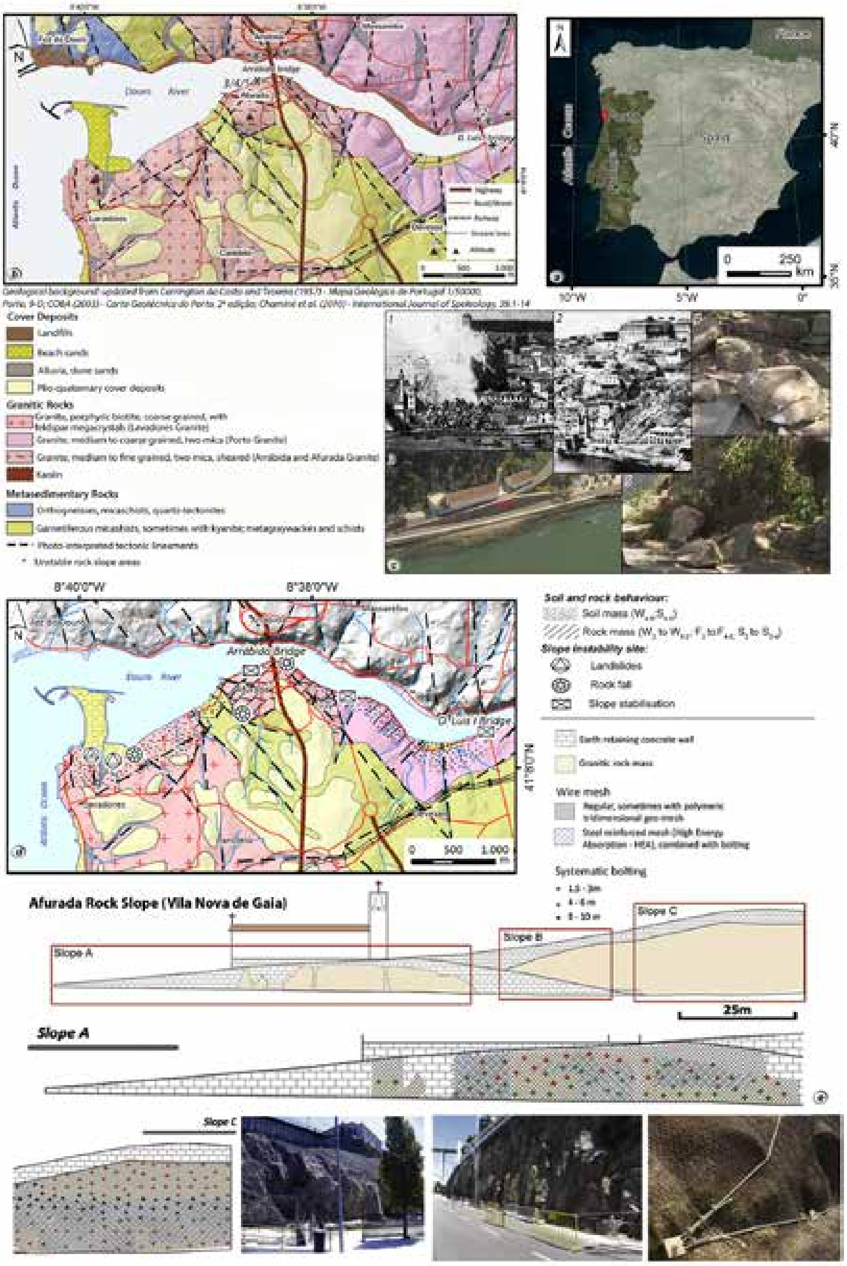

Figure 4: Engineering geological mapping framework and hazard rock slope stability sites for Porto and Vila Nova de Gaia riverside downtown (updated from Chaminé et al., 2010). A, B) Geographical setting and geological background with the main location of unstable rock slope sites; C) 1. Historical rockfall near the Guindais Quay, Porto city, on 27 January 1879 (after the drawing by J.J. Pinto), 2. Photo of Guindais rock slope, before 1881 (kindly shared by the archaeologist Sandra Salazar Ralha), 3. Afurada rock slopes (Rua da Praia, near the S. Pedro da Afurada parish), 4. 5. Rock fall slope failure from Afurada scarp [August 2008]; D) Preliminary engineering geosciences mapping of Vila Nova de Gaia riverside downtown; E) Schematic cross-section of the studied rock slope area (slopes A, B, C) and the basic solution of stabilization adopted. The photos were taken during the stabilisation works and after the stripping of the rock mass (July to August 2009).

Figure 5 shows a preliminary study of the geomaterials of the rocky platform near the Atlantic coastline in the so-called Lavadores beach area (Canidelo, NW Portugal). That coastline comprises a dynamic transition between the marine environment and the terrestrial environment. The Lavadores site is characterised by a mixed coastal system comprising rocky platform with boulders and megaboulders, sandy beaches, breakwaters and groins. Immediately north of this site, a sand spit of about 700 m length occurs, the so-called "Cabedelo", which narrows the mouth of the Douro River. The regional geology of the Lavadores site is comprised mainly of medium to coarse-grained granitic rocks and gneisses. The designation "rocky coast" is currently used to refer to coasts that have fissured rocky substrates in the form of shore platforms with or without coastal rock boulders (Pires *et al.*, 2016; and references therein).

Coastal geoscience mapping, geomorphological features and geomechanical assessment of the geomaterials were incorporated into the coastal environments research to analyse these features in terms of the behaviour of the structure of different layers and rock/block movement. In addi-

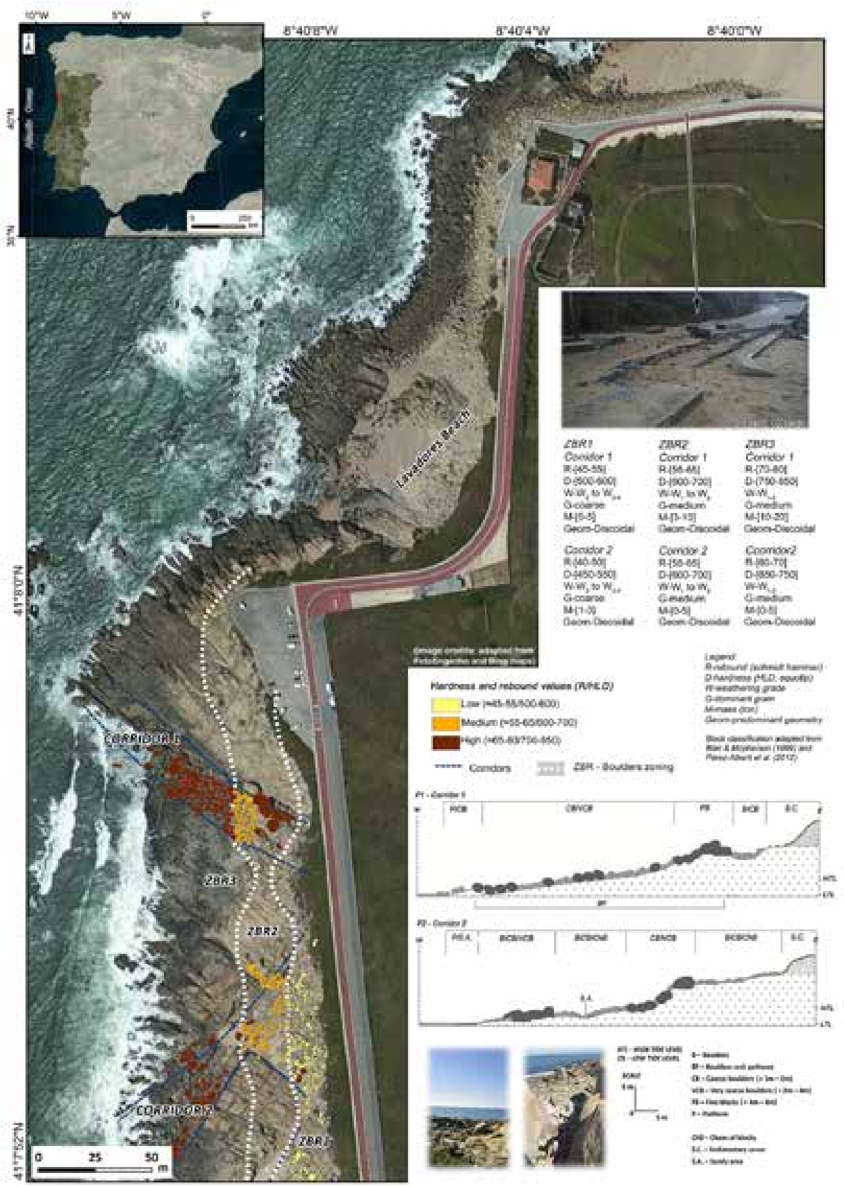

Figure 5: Lavadores rocky coastline (Canidelo, Vila Nova de Gaia, NW Portugal) framework (details in Pires et al.*, 2016): rock beach boulder mapping and hazard effects on rocky coastline (image credits: kindly shared by Professor F. Piqueiro [FotoEngenho Lda] and Bing Maps). Beach profiles P1 and P2 were based on the revised Udden-Wentworth scale to describe the size of boulders and block size of other large rocks. The coastal geomorphic mapping includes a boulder mobility analysis, geoforms inventory and boulder pathways.*

tion, the approach displays an integrated procedure for coupling coastal geoscience mapping and high-resolution digital imagery (acquired by micro drones technology and or airborne surveys) for maritime environmental evaluation (details in Pires *et al.*, 2016). At the Lavadores site a coastal boulder evaluation was made with some identified boulder mobility pathways and their profiles plotted. That approach led to defining a coastal geoscience zoning map based on applied geology, coastal geomorphology and in situ geomechanical investigations, as well as coastal dynamics and rock boulder mobility. Finally, the GIS coastal geoscience maps were very useful to determine zones of vulnerability to coastal erosion and geohazards, to identify hydraulic structure silting up, and to contribute to regional/local coastal planning.

The combined interdisciplinary methodology proved valuable to an enhanced understanding of ground nature and geohazards assessment along a riverside downtown and a coastal shoreline near the Porto and Gaia urban areas. In fact, engineering geosciences mapping play an important role in sustainable urban planning at the municipal scale (Oliveira *et al.*, 2009; Chaminé *et al.*, 2010).

Penafiel site

The selected study site, the Monte do Fogo-Santa Marta granitic rock mass, is located near the Penafiel urban area (NW Portugal). The Monte do Fogo hill is located South of Santa Marta parish (***Fig. 6***). The regional geology comprises Variscan granitic fractured bedrock. There are some prevailing tectonic lineaments (NNE-SSW to N-S and NW-SE). The crystalline basement is also crosscut mainly by dolerite dykes, aplite-pegmatite and quartz veins. Locally, the geomorphology is characterised by steep slopes and entrenched valleys. The drainage network reveals this tectonic control, which imposed morphostructural features on the area.

The Monte do Fogo rock mass comprises porphyritic two-mica granite, coarse grained, and yellowish to grey colour. The outcrops and underground rock masses mapped range from slightly to moderately weathered rock (W_{1-2} to W_3), with highly weathered (W_{4-5}) outcrops observed in the surrounding upper slopes. The rock scanline surveys related to the discontinuity surface conditions can be summarised as: i) fracture intercept (F) is mainly wide to moderate spacing (F_2-F_3); ii) aperture varies from open to closed, iii) persistence is low to moderate; iv) presence of clay and gouge infillings; v) plane to undulating surfaces, low roughness and iron-stained; vi) rock uniaxial compressive strength is low to moderate (S4-S3); and vii) Geological Strength Index (GSI), based on rock structure versus discontinuity surface condition, ranges typically from 60-70 (i.e., very blocky to blocky, interlocked partially disturbed rock mass consisting of orthogonal discontinuity sets and random fractures).

The Monte do Fogo-Santa Marta groundwater systems were assessed by integrating several techniques taking advantage of GIS-based mapping. Vulnerability groundwater mapping (e.g., DRAT index, i.e., susceptibility index derived from hydrogeological and land use parameters) permitted the assessment of the Monte do Fogo rock mass (galleries network around 250 m long and a maximum depth of 25 m below ground level). An extensive hydrogeological inventory was developed on the surface and underground (***Fig. 6***). Some old water mines were part of an impressive water supply system for the Penafiel urban area. These water galleries are mostly situated in the slope hills. The inventoried springs are essentially located in lower areas and have very small yields (0.4 L/s). Local groundwaters have median to low temperatures (ca. 18 ºC), are mainly acidic (pH ~ 5.5), and have low electrical conductivities (ca. 250 µS.cm^{-1}). Groundwaters have very low mineralisations and commonly a sodium chloride to sodium-calcium chloride hydrochemical facies. The hyposaline chemical composition of these groundwaters indicates a very shallow circulation.

The groundwater vulnerability assessment applied to the Monte do Fogo-Santa Marta groundwater systems was carried out in order to fulfil the European and Portuguese Legislations defining strategies for the environmental protection of groundwater resources, namely the definition of protection zones around localised groundwater recharge areas. These areas are necessarily considered as strategic areas of protection in land use planning. As can be seen in ***Figure 6***, overall the groundwater vulnerability to contamination in this region is mostly low to moderate. However, two areas should be highlighted with a moderate to high vulnerability, which correspond to alluvia deposits (SW and SSE of Crasto de Cima). Locally, in the surrounding area of Monte do Fogo-Santa Marta mine water, vulnerability is moderate to low, with the highest values being reliant on mainly urban fabric and forested areas. Accordingly, this methodology permitted the delimitation of three protection areas (immediate, intermediate and extended) for Monte do Fogo-Santa Marta groundwater systems, in order to integrate them in future plans of territorial planning.

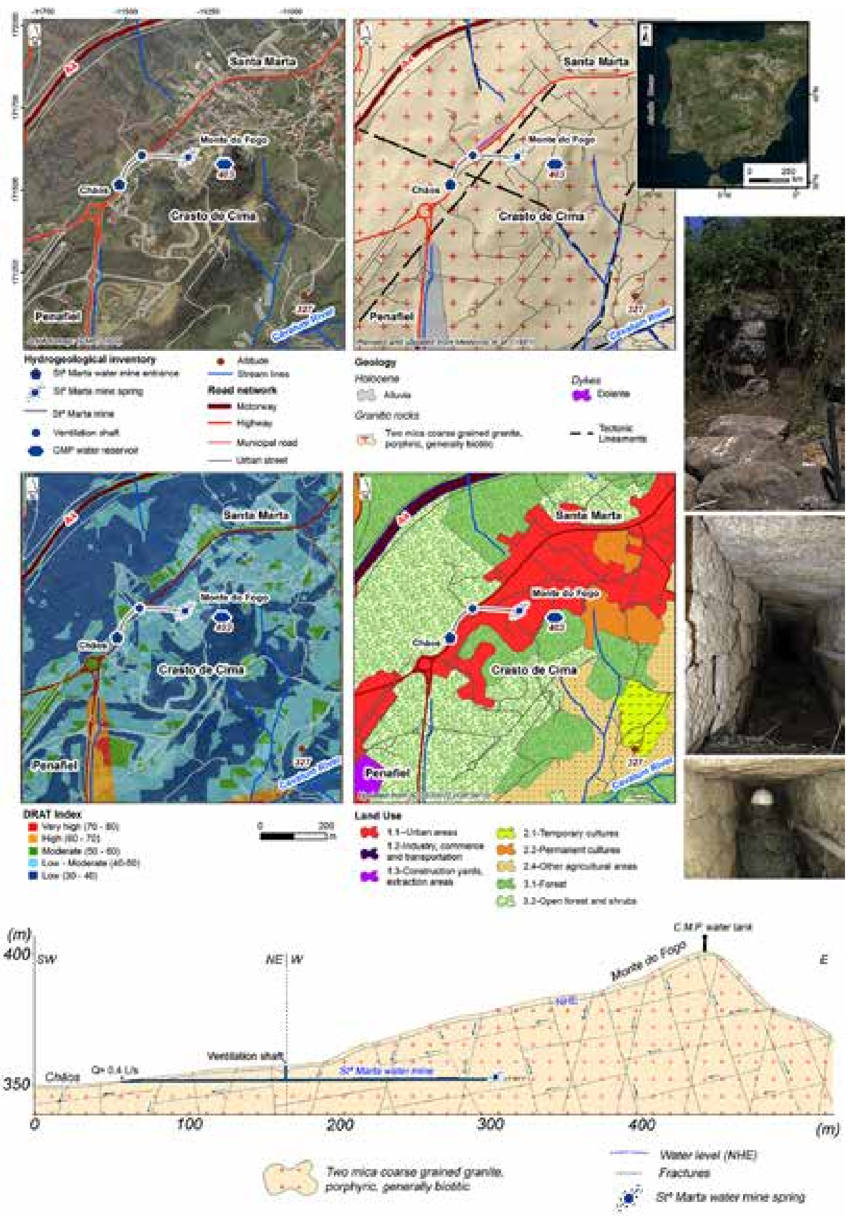

Figure 6: Monte do Fogo-Santa Marta water mine system (Penafiel, NW Portugal) framework: an example of groundwater mapping for urban planning.

Concluding remarks

According to Pain (2016) since the dawn of civilisation, urban areas have brought both benefits and risks to the health and wellness of their inhabitants. Although some of the hazards have been banished, others remain, and new ones have emerged, i.e., the rise of the "urbanite" (Pain, 2016). In that key framework urban geoscience GIS-based mapping is more topical than ever and has high relevance to the following issues: i) it contributes decisively to balanced urban planning decisions grounded in a sustainable design with nature (McHarg, 1992) and heritage (Bandarin and van Oers, 2015); ii) it supports the necessity of a smart urban geosciences approach based on a reliable conceptualisation on geosystems established on cartographic reasoning for a modern digital city, networking nature, geosciences, heritage and society (Chaminé *et al.*, 2014); and iii) communication and dissemination are needed in urban geoscience in a straightforward way to all participants (i.e., practitioners, researchers, stakeholders, decision makers and public) in the planning process (Marker, 2015).

Mapping plays a central role in urban geoscience for in situ geotechnical investigations, ground modelling, urban hydrology, geological resources, heritage and geohazard assessments, and planning purposes. This work highlights the importance of GIS geological engineering mapping as a useful tool to contribute to a balanced urban planning management aiming a sustainable design with nature, environment, heritage and society. This study was focused on the importance of coupling GIS-based mapping and engineering geosciences for urban planning at municipal level. In this approach, urban geoscience studies assume major significance contributing to land/cover use management and planning. Therefore, innovative methodological approaches are required in the survey, collection, analysis, design and modelling of urban data.

The geologist David J. Varnes summarised the overall outlook in an impressive way: *'(…) engineering geologists are admonished nowadays to speak the engineer's language, to put maps in a form that plan-*

ners or even the layman can understand, and to quantify our statements. This is very good, very necessary. But let us also realise that users of our maps may understand us too well; they may see that we extrapolate without giving the odds, that we sometimes map one thing and say it is another without presenting evidence for covariance; and they may be more aware than we that statistical analyses of test results cannot alone serve as reliable measures of in-place heterogeneity. (…) The presentation of quantitative information often is helpful in our effort to gain and hold the attention of engineers, planners, legislative bodies, and other users. But even more important is the need to think and write straightforwardly, logically, and honestly – in a word, clearly. This is more than helpful: it is absolutely essential.' (Varnes, 1974: 41).

Acknowledgements

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On the harmonisation of Serbian classification and accompanying regulations on resources/reserves of solid minerals with the PERC standard

Miloje Ilich and Radoslav Vukas*

The Classification of "Reserves" (in fact: Resources and Reserves) of Solid Minerals and the accompanying Regulations, both contained in The Book of Regulations (1979) - a legal supplement to the former Law (1977), have been officially applied in Serbia up to now, although they were exclusively created for ex-Yugoslavia and its socialistic system. Nowadays they have many shortcomings, are outdated in many aspects and are in disharmony not only with the principal world classifications and the accompanying codes but also with the recent Serbian Law on Mining and Geological Exploration (2015), which has not yet been followed by a supplementary new Book of Regulations. Considering this matter, the authors have proposed a new Classification of Mineral Resources/Reserves and the linked Regulations, both included in a new Serbian Book of Regulations, based on, and harmonised with the PERC Standard (2013).

La classification des Réserves (en fait les ressources et réserves minières) de gisements massifs ainsi que les Régulations associées, les deux contenues dans le Livre des Régulations (1979) – un supplément législatif à la Loi précédente (1977) - ont été officiellement appliquées en Serbie jusqu'à ce jour, bien que créées exclusivement pour l'ex-Yougoslavie et son régime socialiste. Aujourd'hui, elles ont de nombreux défauts, sont désuètes à plusieurs titres et en désaccord avec non seulement les principales classifications mondiales et les codes qui leur sont adjoints mais aussi avec la récente Loi serbe sur l'exploration minière et géologique (2015), qui n'a pas encore été accompagnée d'un nouveau Livre additionnel de Régulations. En considération de cela, les auteurs ont proposé une nouvelle Classification des Ressources et Réserves minières ainsi que les Régulations associées, les deux figurant dans un nouveau Livre serbe de régulations, basé sur et en accord avec la Norme PERC (2013).

La Clasificación de "reservas" (de hecho: Recursos y Reservas) de minerales sólidos y los reglamentos correspondientes, ambos contenidos en el libro de los Reglamentos (1979) - un suplemento legal a la Ley anterior (1977), se han aplicado oficialmente en Serbia hasta ahora, a pesar de que fueron creados exclusivamente para la antigua Yugoslavia y sistema socialista. Hoy en día tienen muchos defectos, no están actualizados en muchos aspectos y faltan de armonía no sólo con las principales clasificaciones mundiales y los códigos que las acompañan, sino también con la reciente Ley serbia de minería y exploración geológica (2015), que aún no ha sido seguido por un nuevo libro de regulaciones suplementario. Teniendo en cuenta esta cuestión, los autores han propuesto una nueva clasificación de los Recursos Minerales/Reservas y los Reglamentos vinculados, ambos incluidos en un nuevo libro serbia de regulaciones, basado en, y armonizado con la Norma PERC (2013).

Mineral Wealth of Serbia and Its Sustainable Use

Serbia has a comparatively small territory (88,361 square kilometers) but a diverse geological composition (including various sedimentary, magmatic and metamorphic rocks, dating from Precambrian up to Quaternary) and a complex tectonic structure (occupying parts of Dinaric and Carpatho-Balkan foldbelts, Vardar Zone, Serbo-Macedonian and Pannonian median massifs, and Moesian Platform), as demonstrated in ***Figure 1***. In the part of the lithosphere, pertinent to the present territory of Serbia, many geological processes have taken place over a wide time span, causing formation of its mineral wealth. This is concentrated in deposits which contain resources and reserves of numerous solid raw materials: metallic and nonmetallic minerals, and solid mineral fuels (coal and oil shales).

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Mining of mineral wealth (from mineral deposits), as a form of land use, has been performed on the territory of Serbia in a long time-period (since prehistoric times). Contemporary mining activity should be sustainable (economically profitable, technically efficient, ecologically safe, socially beneficial etc.) and should be based on a modern, worldwide recognized classification of mineral resources/reserves and the accompanying regulations, both contained in a Book of Regulations (Code Book or Book of Standards) for Reporting of Exploration Results, Mineral Resources and Mineral Reserves.

A Proposal for Harmonisation

The Classification of "Reserves" (an obsolete use of the term that embraces both reserves and resources) of solid minerals (i.e. solid mineral raw materials) and the accompanying Regulations have been in official use in Serbia since 1979, both included in *The Book of Regulations on Classification and Categorization of Reserves of Solid Mineral Raw Materials and Keeping a File on Them* – abbreviated as the 1979 Book of Regulations – which is a legal supplement to the former *Law on the Uniform Method of Establishing, Recording and Gathering Data on Reserves of Mineral Raw Materials and Underground Water and on Their Balancing (1977)* - further referred to as the 1977 Law. The 1979 Book of Regulations superseded all its previous editions.

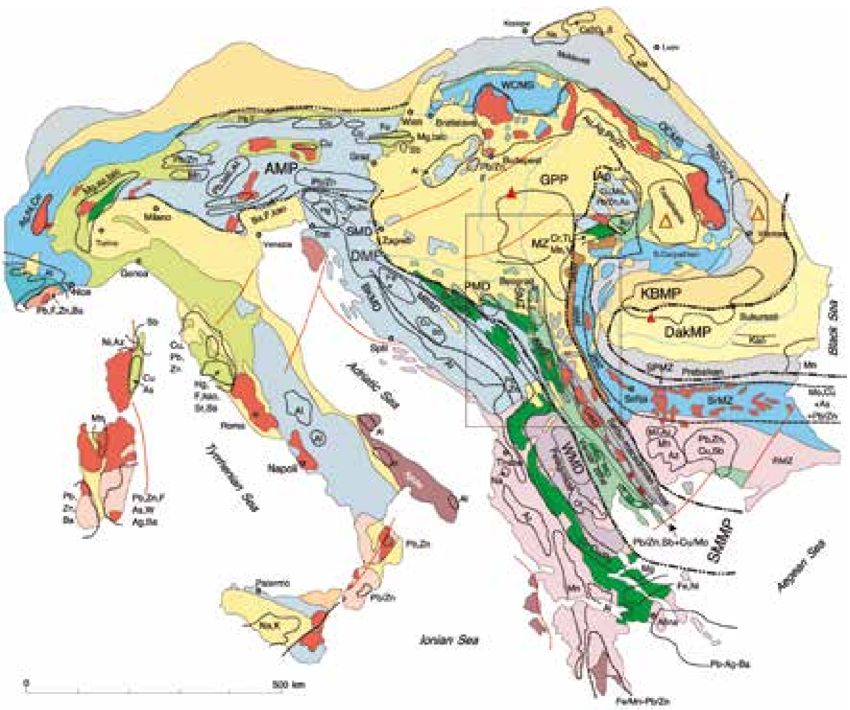

Figure 1: Metallogenic map of Serbia (and surrounding areas): from the Geological Atlas of Serbia (1:2 000 000), Belgrade, 2000.

It should be mentioned that the legislation (both general and particular – regarding mineral "reserves" of that time was intended for ex-Yugoslavia and its socialistic system and the Classification of "Reserves" of Solid Minerals has been solely used in the former Yugoslavia and in the later Republic of Serbia (as a remnant). It should be pointed out that the Soviet Classification, developed and officially used in the former Soviet Union (including socialist countries) and in the later Russian Federation, was taken as a model for the Yugoslavian Classification of "Reserves" of Solid Minerals. Therefore, the Classifications (and the accompanying Regulations) are similar: e.g. on the basis of the Degree of Exploration (and Study) in the Yugoslavian system the "Reserves" are classified into A, B, C_1, C_2, D_1 and D_2 Categories (***Table 1***) and in the Soviet system into A, B, C_1, C_2, P_1, P_2 and P_3 Categories. Nevertheless, the Russian National Association for Subsoil Examination (NAEN) agreed with the Committee for Mineral Reserves International Reporting Standards (CRIRSCO) that Categories P_3 and P_2 correspond to Exploration Results; P_1 to Inferred Resources; C_2 and part of C_1 to Indicated Resources; the the other part of C_1, B and A Categories to Measured Resources, while Exploitation Reserves (inclusive of dilutions and losses during mining and established after consideration of the Modifying Factors) correspond to Probable and Proved Reserves (*The Russian Code for the Public Reporting of Exploration Results, Mineral Resources and Mineral Reserves (2011)*) – abbreviated as the NAEN Code.

However, from the present-day viewpoint, the Serbian Classification and the associated Regulations, as well as the whole embracing 1979 Book of Regulations, have

Table 1: Main elements of the official Serbian Classification of "Reserves" (the term comprises both resources and reserves) of Solid Mineral Raw Materials: compiled from the 1979 Book of Regulations.

Degree of Exploration	CLASSES/CATEGORIES OF RESERVES OBTAINED BY GEOLOGICAL EXPLORATION		STEPS OF GEOLOGICAL EXPLORATION PROCESS		REPORTING TO GOVERNMENTAL AUTHORITIES
			Phases	Stages	
	RESERVES OF SOLID MINERAL RAW MATERIALS				
	Potential:		Basic exploration	Geological analysis and analogy Geological analysis and extrapolation Prospecting	Reports on results of geological exploration
	D_2 Category				
	D_1 Category				
	C_2 Category				
	Established (Geological –*in situ*):		Detailed exploration	Preliminary (general) exploration Detailed exploration Exploration during exploitation	Reports on balance reserves (with technical-economic evaluation)
	Out-of-Balance	Balance			
	C_1 Category	C_1 Category			
	B Category	B Category			
	A Category	A Category			

Technical-economic evaluation (analysis of geological, genetic, technical-exploitation, technological, regional, market and social-economic factors) many shortcomings (listed below), are outdated in many aspects and are in disharmony – regarding principles, standards, terms and their definitions, used in exploration, estimation (assessment, evaluation) and classification of mineral resources and reserves – not only with the contemporary world-ranked classifications and the associated codes (in the first place with the Pan-European Standard for Reporting of Exploration Results, Mineral Resources and Mineral Reserves – abbreviated as the 2013 PERC Standard – the European member of the large CRIRSCO family) but also with the recent Serbian *Law on Mining and Geological Exploration (2015)* – further referred to as the 2015 Law. For that reason the 2015 Law prescribes a two-year-long period (until December 8, 2017) for creating a new Book of Regulations, as its supplement, and bringing it through the legislative process (including public discussion).

A general shortcoming of the 1979 Book of Regulations is that it is too normative and detailed and leaves little room for original solutions in the planning and performing of geological exploration. The Book prescribes obligatory directives concerning exploration methodology (including type, distribution and spacing of exploratory workings and type, distribution and spacing of samples for the appropriate analyses as well as concerning classification, calculation and evaluation of "Reserves" for 43 solid mineral raw materials, divided into several groups of deposits on the basis of their complexity, which prolongs the time needed and increases costs of geological exploration.

The main particular shortcomings of the 1979 Book of Regulations, are the lack of certain contemporary worldwide accepted concepts and terms, such as Mineral Resources, Modifying Factors, Pre-Feasibility and Feasibility Studies, Competent Persons and Public Reports. Although similar terms are used in the 1979 Book, such as "Reserves" – Potential (of D_2, D_1 and C_2 Categories), Established (of C1, B and A Categories) and Exploitational Reserves (of A, B and C_1 Categories), Factors of Technical-Economic Evaluation, Technical-Economic Evaluation, Responsible Persons, Reports on Reserves of Mineral Raw Materials (prepared for the govermental authorities), these terms are defined and employed differently – in accordance with the laws of the former Yugoslavia and its socialist system. It should be stressed that none of the Serbian Categories of Established Balance "Reserves" (of A, B and C_1 Categories) correspond to the PERC Reserves (Proved and Probable) because they do not include dilution and losses that may occur during mining (exploitation). Only Exploitation Reserves are inclusive of the dilution and losses, and thus correspond to the PERC Reserves (***Tables 1, 2 and 3***).

On the other hand, it should be pointed out that the 1979 Book of Regulations, in spite of its shortcomings, has played a significant role, and has contributed to many achievements in exploration, estimation (assessment, evaluation), classification and keeping evidence of resources/reserves of

Table 2: Main elements of the proposed new Serbian Classification of Resources/Reserves of Solid Minerals intended for the new Serbian Book of Regulations, based on, and harmonised with the Classification contained in the 2013 PERC Standard.

Increasing level of geological knowledge and confidence

RESULTS OF GEOLOGICAL EXPLORATION AND SOLID MINERAL RESOURCES/RESERVES	SUCCEEDING STAGES OF GEOLOGICAL EXPLORATION AND THE PERTAINING STUDIES	REPORTING OF THE RESULTS	
RESULTS OF GEOLOGICAL EXPLORATION	Reconnaissance/Preliminary Estimation	Annual Reports, Final Report (to Governmental Authorities)	Public Report
MINERAL RESOURCES / MINERAL RESERVES			
Inferred	Prospecting/Opportunity (Scoping) Study	Annual Reports, Final Report (to Gov. Auth.)	Public Report
Indicated ⟷ Probable	Preliminary (General) Exploration/Pre-Feasibility Study	Annual Reports, Final Report (to Gov. Auth.)	Public Report
Measured ⟷ Proved	Detailed Exploration/ Feasibility Study	Annual Reports, Final Report (to Gov. Auth.)	Public Report
	Exploration During Mining/ Special Geological and/or Mining Studies	Annual Reports. Mining Report. (to Gov. Auth.)	Public Report

Consideration of the „Modifying Factors" (mining, processing, metallurgical, infrastructure, economic, marketing, legal, environmental, social, and governmental factors)

Table 3: Correlation and conversion map of categories and classes of resources/reserves of solid minerals from the classifications contained in the 2009 UNFC, in the 1979 Book of Regulations and in the proposed new Serbian Book of Regulations (based on Ilich et al, 2012, supplemented by the present authors).

Proposed New Book of Regulations for Solid Mineral Raw Materials	**Results of Geological Exploration**	**Mineral Resources**			**Mineral Reserves**	
		Inferred	**Indicated**	**Measured**	**Probable**	**Proved**
Official Book of Regulations for Solid Mineral Raw Materials (1979)	**Mineral Reserves**					
	Potential	**Potential**	**Established** ***(in situ* – Geological: *Out-of-Balance and Balance)***		**Exploitation** ***(inclusive of dilutions and losses during mining)***	
	D_2, D_1	**C_2**	**C_1**	**B,A**	**C_1**	**B,A**
UNFC (2009)			**Mineral Resources**		**Mineral Reserves**	
	334	**223**	**222**	**221**	**112**	**111**

Serbian solid mineral raw materials. These achievements should be appreciated and used regardless of legislative changes.

The aforesaid achievements are: general division of geological exploration into basic and applied exploration; performing of geological exploration in stages: prospecting, preliminary (general) exploration, detailed exploration and exploration during mining; determining the degree of exploration of a mineral deposit; the optimal percentage of different classes of mineral resources and reserves in a certain stage of geological exploration, and the legal obligation that a special kind of reports on exploration results and mineral resources/reserves should be submitted to the Serbian governmental authorities (for monitoring, taxation, the state balance (evidence) of resources/reserves etc.). In this connection two kinds of reports are distinguished: for governmental authorities and for public reporting (***Tables 1 and 2***).

It should be emphasized that the recently passed 2015 Serbian Law recognises the terms: Mineral Resources (Inferred, Indicated and Measured) and Mineral Reserves (Probable and Proved), Competent Persons and Public Reports. However, the 2015 Law has not yet been followed by the new supplementary Book of Regulations on Mineral Resources/Reserves which would give complete definitions and explanations. It also does not repeal the 1979 Book of Regulations but prolongs its legality for two years (up to December 8, 2017) by which time the new one should have been adopted. Therefore, a serious problem arises at the present time: the current 2015 Law and the still valid 1979 Book of Regulations are in mutual discord regarding the principles, standards, terms and their definitions, used in exploration, estimation (assessment, evaluation) and classification of mineral resources/reserves.

The authors considered this matter in several papers (Ilich *et al.*, 2009, 2011, 2012; Vukas, 2009) and reached the conclusion that it is necessary to create a new, contemporary Serbian Classification of Resources/Reserves of Solid Minerals and the associated Regulations, both to be included in a new Book of Regulations on Reporting of Results of Geological Exploration, Resources and Reserves of Solid Mineral Raw Materials and Their Classification. Therefore the authors proposed the new Classification and the linked Regulations intended for the new Book of Regulations, which would be based on, and harmonised with the 2013 PERC Standard (which superseded all previous editions of the PERC Code).

Since the 2013 PERC Standard sets out minimum standards (with recommendations and guidelines), national Code Books, harmonised with the Standard, could be supplemented by the addition of certain matters of national interest, on the condition that they are not in discord with any part of the Standard. A good example of that is the actual Russian NAEN Code (2011), harmonised with the CRIRSCO and the PERC codes, which contains many additional Russian matters which are acceptable to the codes. Accordingly, certain matters significant to Serbia might be included in the new Book of Regulations. The authors paid attention to the United Nations Framework Classification (UNFC), as one of the leading world classifications, which is also harmonised with the CRIRSCO and the PERC codes.

Since the 2015 Law prescribes creating a new Book of Regulations by December 8, 2017, the discussions and the proposals about its contents should be presented in a timely manner. Our considerations, conclusions and the resulting proposal concerning the matter are presented below. A brief comparative survey of different classifications of resources/reserves of solid minerals, both Serbian and those accepted by the leading global organizations, is displayed in ***Tables 1, 2 and 3***. The classifications from the official 1979 Book of Regulations (***Table 1***) and from the proposed new Serbian book of regulations (***Table 2***) are presented and a synthesised map of correlation and conversion of the categories and classes of solid minerals is exhibited in ***Table 3***.

Benefits of Harmonisation

The proposed new Serbian Classification of Resources/Reserves of Solid Minerals and the linked Regulations, both included in the new Book of Regulations, have been created as a supplement to the 2015 Law based on, and harmonised with the 2013 PERC Standard (as the European member of the CRIRSCO family that comprises the leading world reporting codes, such as PERC, JORC, CIM, SME, SAMCODES, NAEN). The new Classification and Regulations would be beneficial to the country for the following reasons:

- The new Book of Regulations would have contemporary content and form, and would employ principles, standards, terms and their definitions, used in exploration, estimation (assessment, evaluation), classification and reporting of mineral resources/reserves that nowadays are applied in Europe and worldwide. It would replace the official 1979 Book of Regulations, which has a local character (aimed at one country), has many shortcomings, is outdated in many aspects and is in disharmony both with contemporary world reporting codes and with the recent Serbian 2015 Law.

- The data regarding Serbian mineral resources/reserves that were gathered, evaluated and classified in the period of application of the 1979 Book of Regulations could be converted into the form required by the 2013 PERC Standard, so that they would be clear to foreign experts, advisers, stockholders and stockbrokers, and other interested persons.
- It would enhance sustainable use of Serbian mineral wealth by applying European and world standards and experience concerning economically profitable, technically efficient, ecologically safe and socially beneficial mining of solid mineral raw materials from Serbian deposits as well as adequate space planning, land use, environmental protection, social care, etc., connected with the mining activity.
- It would advance co-operation between Serbia and foreign countries in the fields of exploration, estimation (assessment, evaluation), classifying and reporting of mineral resources/reserves and mining of solid mineral raw materials, performed by various institutions, companies, investors, banks and stock markets as well as by individuals.

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Pravilnik o klasifikaciji i kategorizaciji rezervi čvrstih mineralnih sirovina i vođenju evidencije o njima (The Book of Regulations on Classification and Categorization of Reserves of Solid Mineral Raw Materials and Keeping a File on Them), Službeni list SFR Jugoslavije br. 53/1979.

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Zakon o jedinstvenom načinu utvrđivanja, evidentiranja i prikupljanja podataka o rezervama mineralnih sirovina i podzemnih voda i o bilansu tih rezervi (The Law on the Uniform Method of Establishing, Recording and Gathering Data on Reserves of Mineral Raw Materials and Underground Water and Their Balancing), Službeni list SFR Jugoslavije, br. 53/1977.

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Challenges and opportunities with charging for geological information in land use planning

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Land use should meet current and future societal needs while keeping conflicts bounded and functional (e.g. at a minimum). Analysis of mapped data has become an important part of understanding and managing land use. This paper discusses the economic characteristics of geological information in relation to land use conflicts and the impact of adopting different pricing models for the provision of geological information. Moreover, we highlight some aspects that may make geological maps less pertinent than other geoinformation sources, given the often scarce data, slow diffusion and the high cost of investing in additional information.

L'aménagement territorial doit répondre aux besoins actuels et futurs tout en conservant la maitrise des opérations (réduisant les conflits à un minimum). L'analyse des données cartographiques est devenue un élément important de la compréhension et de la gestion de tout aménagement. Cet article étudie les caractéristiques économiques des informations géologiques en connexion avec les conflits d'aménagement et l'impact lié au choix de modèles de prix différents en fonction des données géologiques. De plus, l'accent est mis sur quelques points qui peuvent rendre les cartes géologiques moins pertinentes que d'autres sources d'information géologique, étant donné la rareté occasionnelle des données, leur lente diffusion et le coût élevé de l'investissement dans la recherche d'une information additionnelle.

El uso del suelo debe cumplir con las necesidades sociales actuales y futuras , delimitando los los conflictos y funcionalidad (a un nivel mínimo por ejemplo). El análisis de los datos cartográficos se ha convertido en una parte importante de la comprensión y la gestión del uso del suelo. Este documento analiza las características económicas de la información geológica en relación con los conflictos del uso del suelo y el impacto de la adopción de diferentes modelos económicos en la información geológica suministrada. Por otra parte, se destacan algunos aspectos que pueden hacer que los mapas geológicos sean menos pertinentes que otras fuentes de geo-información, teniendo en cuenta los datos a menudo escasos, la difusión lenta y el costo alto de la inversión en informaciones adicionales.

Society demands adequate information on many complex and interrelated aspects of its activities. Land use management has therefore become increasingly important in order to overcome the problems connected to urban development and deteriorating environmental quality. While delivering both sustainable development and livable communities, land use should keep conflicts at a minimum. In this paper we discuss the economical characteristics of geological information, in relation to land use conflicts, and the potential impact of different pricing models on the provision of information.

Information goods are characterised by large sunk costs of development and negligible costs of reproducing and distributing.

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The bulk of the costs are up front, in part since the gathering of new information is labour intensive and requires skilled staff. The production costs of the first unit are very high, but thereafter the cost of additional copies is very low. Due to this the production of geological information leads to a natural monopoly. Geological information is therefore mainly collected by government-funded geological surveys.

Although geological information is assumed to be non-rival in consumption, the information can be excludable through licensing. This implies that even if relevant data on land changes exists, it may not always be included in the land use planning, since all additional data comes at an additional cost. Land use measurements help resolve how to utilise the available land resources for food, shelter, development, conservation, etc. If not all relevant aspects of a region are considered, it is likely that some groups or interests will be excluded from the planning process, which in itself increases the risks of conflicts.

On the other hand freely available data, and the transparency it enables, might be deliberately misinterpreted by some individuals or groups as promoting socially undesirable outcomes (Bannister and Connolly, 2011).

Market challenges due to pricing structures

The literature on geospatial data and pricing models tends to include monopoly pricing, cost recovery (full or price discriminative) and marginal cost (see summary in ***Table 1***). Monopoly pricing implies a high uniform price and aims to provide profit for the government. In the cost recovery models the data are priced to recover most of the costs of producing, maintaining and distributing. Each new user is required to get a license at a price that enables the producer to recover the full cost of the data. This implies that the producer has prior knowledge on all purchases and this is taken into account when pricing. Under full cost recovery the geological information should not require direct public sector funding since the average long-run cost will be covered; however, few agencies have even aimed at full coverage of costs. Given a price discriminative cost recovery model, additional governmental funds will be needed. Marginal cost implies a uniform low price set to recover cost of distribution and is at least initially dependent on additional governmental funds. Under the monopoly pricing and cost recovery models the agencies maintain strong control over the re-use and distribution of data. However, this implies that the producers are the ones best suited to determine how the data could be applied.

In Sweden public sector information, such as geological information, is governed by three interacting principles: freedom of information, privacy and cost recovery (Pira, 2000). Cost recovery is a means used by governments to minimise the cost related to public sector information. This is far from the best approach for maximising the economic value of the information, nor is it the best method to finance data products (Weiss, 2002). For instance, access barriers due to charging structures lead to lower demand compared to cases with freely available information.

A challenge facing many geodata agencies is the lack of transparency in implementing key cost recovery practices. POPSIS (2011) found that the calculation bases for determining public sector information (PSI) re-use charges were weak and in some cases the cost setting seems to be oriented towards filling budgetary gaps rather than geared to the cost-oriented tariffs required by the PSI directive. Swedish geodata cooperation has a weak basis for the current price setting model. For instance, the Swedish municipalities are categorised into 9 groups based on population density, geographical area and informational need. Depending on the categories the municipality is charged between 11,489 and 126,778 euros for an annual license on geodata. This is certainly an effort to set third degree price discrimination, yet it is unlikely such prices will accommodate the consumer and promote further information dissemination. Such charging strategies will also result in circular payments among government entities and may lead to use of inferior alternatives due to budget constraints. The cost of geodata may result in agencies ignoring available information and instead creating their own, manipulating or degrading the data to avoid licensing restrictions. This in turn could imply increased internal expenses and create long-term integration issues.

The elasticity of demand indicates how a change in the price of the product will lead to a change in the quantity demanded. Geological information has a high price elasticity, which further supports marginal cost pricing. High elasticity suggests that cost recovery pricing will lead to large distortions. For instance, the early attempt by the USGS to increase its cost-recovery levels in the 1980s by increasing the price of digital maps led to a precipitous drop in demand. The return to initial price levels was not enough and the market took some years to recover to initial levels (Weiss, 2002). Since the Landsat data were made freely available in 2008 the numbers of demanded maps sky rocketed, from 38 to 5700 scenes a day (NGAC, 2012). The downstream effects of the Landsat data being available cannot be overstated and has set an example for data accessibility to be adopted by other governmental agencies. Pira (2000) finds that a conservative projection of a doubling in market size resulting from eliminating license fees would produce additional taxation revenues to more than offset the lost income from public sector information charges.

The European Directive on the re-use of public sector information (2009/98/EC) aims at facilitating re-use by harmonising the relevant conditions across the European Union and removing unnecessary barriers to re-use in the internal market. The provision on charging for public sector information (PSI) was one of the most contested elements of the directive. The revised version of the directive (2013/37/EU) suggested movement towards limiting the ability of governmental bodies to

MODEL	MONOPOLY PRICING	COST RECOVERY (full)	COST RECOVERY (price discrimative)	MARGINAL COSTS
PRICE SETTING	**UNIFORM** (high)	**UNIFORM** (high)	**DISCRIMINATIVE** (among users)	**UNIFORM** (low)
CHARGING POLICY AIMS TO COVER	ALL COSTS AND TO GENERATE PROFITS	AVERAGE LONG-RUN COSTS	SOME LONG-RUN COSTS	MARGINAL COST OF DISTRIBUTION
NEED GOVERNMENT AL FUNDS	NONE	NONE	SOME	SOME
DEMAND	**RESTRICTED** (low)	**PREDETERMINED** (low)	**PREDETERMINED** (medium)	**BOUNDLESS** (high)

Table 1: Pricing models.

charge more than marginal costs of information. However, in the end the revised version still provides exceptions for governmental bodies that are required to cover a substantial part of the cost from revenues. This suggest that those currently under cost recovery structures can unfortunately continue charging for their information. The current pricing regime is also likely to create a barrier to usage in itself due to perceptions within the municipalities charged with a high license fee, given that potential gains from including the information in their land use planning are neither immediate nor certain.

Regardless of regional differences, there is a trend in Europe towards lowering charges and/or facilitating further re-use of geospatial data (de Vries, 2012). This could be due to the growing body of literature which suggests that changing from cost recovering or monopoly pricing to marginal cost models has beneficial impacts on both the society (e.g. employment, economic growth) and also the information sector due to the increased market. While some governments are willing to support the transformation towards marginal charges, the power to perform such changes is not always as prevailing, given the potential need of temporarily increased funding. In addition, current re-users may have interests in preserving the current cost scheme to keep entry barriers high and thus reduce competition.

It could be argued that if additional governmental funding is not met when transitioning from cost recovery to marginal prices, there may be deterioration in the data quality over time, implying that the benefits of the data would decrease. While the value of most information degrades over time, the value of geological data is likely to remain stable in the case of land use management, since the information often include long time series. Cases from the information field suggest that intensified ties with re-users may instead lead to improved data quality and process efficiency. This assumes that deficiencies in the data are flagged by users, suggesting that when the interest in quality is shared the control is also partly shared (POPSIS, 2011).

Value-added products

An important public policy issue is whether governmental agencies, primarily funded by the taxpayers, should produce value-added products that compete with the private sector. Weiss (2002) gives an example on how degraded data was sold to private sector weather services at a lower quality than the data used in the public service's own operations. By doing so, the governmental agencies create unfair competition through unnecessary modifications. The solution to this issue in several countries has been to separate and privatise the commercial part of their operations, which does not solve the problem of them having a dominant position in the market. High prices for information may lead to predatory practices and the creation of government-owned corporations may serve to exclude others from the market. This approach suggests movement towards an open data policy, since the spin-off commercial companies will need to fend for themselves against competition, and the only way to guarantee a "level playing field" is through an open data policy.

We agree with the literature suggesting that levelling the field without unfair competition and cross-subsidisation may be impossible in the case of governmental agencies providing commercial services. Commercial information services should only be provided by the governmental agencies when there is a public need for such services, no private company is already providing that service, and it is deemed unlikely that any private firms aim to pursue it in the near future.

Opportunities for information dissemination

The role of any government in making collected information available is a policy issue. The current trend is moving away from the essence of the British "Rayner doctrine", where it was assumed that if you need data you will pay for them and otherwise you do not need them (Blakemore and Craglia, 2006). Nowadays, the discussion is more often on how to encourage using additional information sources. However, missing in such discussions is the encouragement of additional users, i.e., aiming for broader diffusion of the information. A "build it and they will come" mentality has been prevailing in the literature, suggesting that if only the data are released anyone can use them. This is highly unlikely, as the threshold of understanding geological information implies a learning-by-using cost, which is non-negligible. More normative research claims that making data accessible to a broad public would in itself be a substantial task, but for the public to embrace the openness, the data needs to be usable by all, not only made available to all. The data framework should therefore ensure that user-friendly settings are provided and that the end customer only pays a marginal cost for the use of data. This will minimise the initial opportunity cost of trying the information.

Over the last decade there has been a significant increase in the geoinformation available to support land use planning. While there is a growing body of literature on user-generated geodata, the same investments have not yet been made for geological information. If initial data were available freely, this could spur additional user- generated content, which – given that many users might contribute – also opens up the possibility that the maps may be kept more up to date. However, for the case of land use management there is a need for consistency and the validation of results is needed. Investing in structures that enable user contributions has the potential to lower the cost of such information in the long term. Moreover, increased availability of land user data could enhance participation and democracy as it can facilitate communication (Blakemore and Craglia, 2006). By providing actors with symmetric information concerning land use, it would be possible to further minimise the risk of conflict, as the interested parties can participate in the process.

Concluding remarks

Due to some of the fundamental economic characteristics of information (e.g. high elasticity of demand, non-rival consumption) it should be questioned whether governmental agencies producing geodata can successfully raise enough revenue to pay not only for the dissemination of its information but also for the costs associated with creating such information. Charging a marginal cost of dissemination for geological information has the potential of creating economic growth that could outweigh the immediate perceived benefits of aggressive cost recovery. Open data does not rest on new technological advancements but rather is seen as raw material for new products. Accessible geological information can contribute to sustainable land use development. By optimal use of geological information it is possible to create a good living environment, facilitate economic development and contribute to the sustainable management of natural resources.

Knowledge gained from using geological information can be considered as augmented by use if the cost of learning is not considered too high. We therefore argue that core geological map data should be licensed at low cost to encourage use, standardisation and consistency among all user groups. The example of the Landsat data confirms the high elasticity of demand for geological information and showcases how data accessibility can be adopted by other governmental agencies.

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Defining Mineral Deposits of National Interest – The Case of Sweden

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The exploitation of minerals in Europe is a necessary activity for securing continued growth and development of the European society. In order to ensure this, it is vital that access to mineral deposits is safeguarded, which is why there is currently an increased focus on "defining mineral deposits of public importance" in Europe. However, there are a number of countries that have already defined mineral deposits of public interest on a national level, for example Sweden. The main purpose of this paper is to analyse the definition of mineral deposits of national interest in Sweden. The paper further aims at discussing the value of geological information in this process.

L'exploitation des ressources minières en Europe est une activité nécessaire pour garantir le développement continu à la fois économique et social, européen. Pour être sûr de cela, il est vital que l'accès aux gisements soit sauvegardé, ce qui explique pourquoi, il y a actuellement un désir croissant de définition des gisements jugés d'importance générale, en Europe. Cependant, certains pays ont déjà identifié les gisements miniers d'intérêt général, au niveau national, la Suède par exemple. L'objectif principal de cet article est d'étudier les critères de définition propres à ces gisements miniers d'intérêt national, en Suède. Pour cet exercice, l'article va plus loin en analysant la valeur de l'information géologique.

La explotación de minerales en Europa es una actividad necesaria para asegurar el crecimiento y desarrollo continuo de la sociedad europea. Con el fin de asegurar esto es vital que el acceso a los depósitos minerales se proteja, por lo que actualmente existe un mayor enfoque en "la definición de los depósitos minerales de importancia pública" en Europa. Sin embargo hay una serie de países como por ejemplo Suecia que ya ha definido los depósitos minerales de interés público a nivel nacional. El propósito principal de este trabajo es analizar la definición de los depósitos minerales de interés nacional en Suecia. Además el artículo tiene por objeto discutir el valor de la información geológica en este proceso.

Minerals are indispensible for our daily life, considering all the products that we use, but also regarding infrastructure development (e.g., roads and buildings) in the region that we live in. The exploitation of minerals in Europe is thus a necessary activity for securing continued growth and development of the European society. In order to ensure this development it is vital that access to mineral deposits is safeguarded, in a similar manner as to many other land use interests (such as e.g. nature protection). The project MINATURA2020, funded by Horizon 2020, was created as a response to this need. This project has the overall objective to "develop a concept and methodology for the definition and subsequent protection of 'mineral deposits of public importance' in order to ensure their 'best use' in the future"[1].

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A number of EU membership countries have already defined mineral deposits of public interest, but on a national level. One of these countries is Sweden, which has had a national definition of mineral deposits of national interest since the 1980s (SGU, 2016). Sweden has a long tradition of mining and is currently one of the EU's leading ore and metal producing countries. For example, it is the largest producer of iron ore and lead, and the second largest producer of silver and zinc (SGU, 2015). During the most recent commodity boom the mining industry has experienced strong growth, and the mining industry is of substantial importance to the country's economy. From a regional perspective, it provides job opportunities in parts of the country with otherwise low growth prospects. A large part of Sweden is part of the Fennoscandian Shield, which is a rock formation that contains large ore deposits. The mineral deposits are further considered to be of high quality from a building and material perspective. Sweden is thus a country with large mineral potential, and it has a long history of negotiations between mining interests and other competing land use interests.

From a European perspective it is important to consider previous knowledge and experience in regards to defining mineral deposits, as important lessons can be learnt. The main purpose of this paper is thus to analyse the definition of mineral deposits of national interest in Sweden. The paper further aims at analysing the value of geological information in this process.

1 For more details about the MINATURA2020 project, see ***http://minatura2020.eu/***.

Sweden's mineral strategy

The main objective of the Swedish mineral strategy, presented in 2013, is to provide a future vision and policy of the Swedish mining industry. One of the main goals of the strategy is to strengthen Sweden's position as one of EU's leading mining and mineral countries. It is further recognised that Sweden's mineral resources should be exploited in a sustainable way, considering long-term impacts on the environment and the social and cultural situation. In order to achieve this strategy, five strategic objectives are identified as crucial, and different measures to achieve these are discussed (Government Offices of Sweden, 2013).

In the mineral strategy it is further stated that, according to estimates from the Geological Survey of Sweden (SGU), there is potential for 30 active metal mines in Sweden by 2020, and 50 active mines by 2030. This should be compared to the current number of 17 active mines. These estimations are based on appraisals of mining capacity in mining projects that have been granted or applied for mining permits (exploitation concessions). The mining potential numbers thus assume that these projects will in fact become active mines (Government Offices of Sweden, 2013). When the mineral strategy was presented, these estimates were considered ambitious. Today, a few years after the strategy was introduced, it can be concluded that Sweden will not reach 30 active metal mines by 2020. In that sense, the mineral strategy can be seen as a failure. However, the strategy can still be seen as an important statement from the Swedish government, i.e., that the mining industry is of high importance for the country.

Mineral planning policy

The mineral planning policy in Sweden is based on national interests. National interests originate from the physical planning process first presented in the Governmental report "Land and Water" (SOU, 1971:75). The main motivation for the development of national interests was that between 1950 and 1970, economic growth was exceptionally strong in the country, which led to a major urbanisation process. This development increased claims on natural resources, which in turn increased the pressure to consider different areas of national interests in Sweden. The purpose of the national planning process was to gain a better understanding and knowledge of Sweden's natural resources. The Natural Resources Law, which entered into force in 1987, was strongly linked to spatial planning. In the same year the Planning and Building Act was introduced, in which the municipalities were granted primary responsible for the planning of land and water areas. When the Environmental Code came into force in 1999 the national interests were transferred there (SGU, 2016).

There are 11 national interests defined in Sweden, of which mineral deposits (in Sweden defined as "deposits of substances or materials") is only one. Areas containing deposits of substances or materials that are of national interest shall, according to the Environmental Code, be protected against measures that may hinder their extraction. Requirements for a deposit to be considered as of National Interest are that it is of great importance for the country's security of supply, that proper documentation of the deposit exists, and that the deposit has special characteristics. In such areas, the local and state authorities are not allowed to plan for, or allow, operations that can prevent or significantly hamper utilisation of the resources. SGU are responsible for the deposits of national interest and they identify deposits of ores, industrial minerals, aggregates and natural stones. There are a total of 145 deposits of national interest already defined in Sweden (as of March 2016), and the majority of these are in the categories of ores and industrial minerals. Of the defined deposits of national interest, 85 are mapped in detail (SGU, 2016).

SGU performs continuous work to demarcate deposits that are defined to be of national interest. This involves deposits that had previously only been marked with coordinates, but also newly discovered deposits being assessed can be classified as of national interest. SGU also works continuously to revoke deposits that may no longer be considered to be of national interest under Chapter 3, Section 7 of the Swedish Environmental Code. A detailed demarcation begins with SGU developing geological background material about the deposit. Information such as production and material properties can also be obtained from the deposit's owner or those operating on the deposit. Following this, SGU personnel inspect the deposit and a preliminary demarcation is drawn up.

A deposit is considered to be of national interest if it satisfies the following criteria:

1. the deposit is relevant to the needs of society on a national level, or of particular regional importance, in terms of employment, economic development and resource supply in the long term.
2. the deposit has particularly valuable properties, as regards e.g. purity, composition, quality, appearance, technical features or volume,
3. the area containing the discovery of the deposit is well defined, examined and documented.

Further noted in the process of defining deposits of national interests is that a long-term perspective should be applied, with a planning horizon of between 50-100 years (SGU, 2016).

The *first* guiding criterion for the definition of deposits of national interest focuses on long-term raw material supply. The deposit has to be important from an economic perspective (for the needs of the community). Knowledge of where the deposits are located is important in the municipal planning processes, in order to avoid planning activities that will hinder future exploration. It is further noted that in case of conflict between different interests an economic assessment of the different activities should be performed. Furthermore, it is stated that the impact on employment and economic growth should be given great significance, and it is important that long-term expansion of production, investment and employment are made possible. The implications for regional balance and the distribution of living standards in the country must also be considered in the assessments.

Regarding raw material supply, i.e., aggregates, rock (crushed or natural stone) and gravel, the above criterion implies that the needs of society, including employment and economic development, are in focus. The region's population structure and growth rate, e.g., construction of housing and infrastructure, need to be accompanied with a secure supply of aggregates. Furthermore, infrastructure and housing in a metropolitan region are of importance for the entire country, which implies that raw material supply in this region can be of national interest. Infrastructure investments, construction projects, or industries are often strategically valuable both for the region and the nation. The definition of national interest is in this context an important tool for the planning of material supply.

The *second* criterion is that the deposit in question must be of a certain volume and/or quality in order to be able to support the country, or part of the country, in the long run. Included in the concept "valuable substances or materials" are those substances and materials that are valuable from an economic point of view. The deposit should thus be "economically recoverable" mineral raw materials, which are needed in industry, energy supply and construction works. In addition to ores, this can include industrial minerals, mineral raw materials on the seabed, and sand and gravel that are available in urban areas. Regarding raw materials supply, valuable properties of the materials that are necessary for the intended use are considered, such as their homogeneity, composition, particle size distribution, technical features, appearance, colour, fractures, structure and volume.

The *third* criterion regards the geological conditions of the deposit, i.e., how it is estimated spatially. This is an important parameter for the definition. It is clear from the legislative history that only natural resources that are well documented should be given protection. SGU produces documentation of cases through systematic work in which they combine geological knowledge of the deposit with the information that companies report from prospecting and extraction of mineral substances. However, it is always SGU that is responsible for the documentation that forms the basis of a national interest classification.

The value of geological information

The value of high quality geological information is obvious in the process of defining mineral deposits of public importance, as it is a prerequisite to the actual definition. In the Swedish definition of mineral deposits of national interest, the third criterion in fact states that the discovery of the substance or the material has to be well defined, examined and documented. In Sweden SGU is responsible for advanced geological data. Material produced during state-financed mineral exploration over the last one hundred years is stored at the SGU Mineral Resources Information Office in Malå. Since state-financed exploration ended in 1993, only private companies carry out exploration in Sweden (although LKAB is a state-owned company). In 2012 the Government allocated extra funding to SGU of SEK 30 million (EUR 3.6 million) per year over four years, in order to further improve geological data in the northernmost counties of Västerbotten and Norrbotten (the Barents Project). Measures that should be implemented included the digitalisation of archive material and the scanning of core samples (Government Offices of Sweden, 2013).

From a European perspective the quality of geological information is an important aspect to consider when defining mineral deposits of public importance. There is thus a need to assure that member countries have high quality geological information, since a definition based on poor quality data will not be accepted by the public. From an economic perspective geological information possesses clear public good features, such as being non-rival (Häggquist, 2015). The information is non-rival since use by one individual does not reduce availability to others. The information can be restricted through licensing, which leads to the definition of a quasi-public good. This influences the assessment of the economic value, since it is not limited to the financial profitability of a given project alone; rather its value to a broad range of users should be acknowledged. Furthermore, the perceived benefits of using geological information differ across users according to which interest they represent (Longhorn and Blakemore, 2008).

The public good feature of geological information implies that it is often difficult to finance production of data, as the individual value of the information is much lower than the public value of this good. Due to this reason, national geological surveys are often state financed. However, there is a tendency, which for example is the case in Sweden, that the geological survey no longer produces mineral data. In Sweden, the companies that do exploration work in the country are required to provide their data to SGU. This is, however, not the case for all European countries. This development is recognized as a potential problem for the subsequent definition of mineral deposits of public importance.

Conclusions

The main aim of this paper was to analyse the definition of mineral deposits of national interest in Sweden. The definition of mineral deposits of national interest in Sweden is recognized in the Environmental Code, which implies that the safeguarding minerals are at a statutory level. Furthermore, the implementation is done in a land use planning context. This is something which would be beneficial also from a European perspective. Another important conclusion is that high quality geological information is a prerequisite for the actual process of defining mineral deposits of public importance in Sweden, as it is recognised that it is difficult to assess the 'national interests' of something that is not well defined. However, considering the public good feature of geological information, in combination with the current trend of less state-financed production of geological information, there is a risk that the quality of geological information will not be sufficient in all European countries.

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News from the Portuguese Association of Geologists

*Mónica Sousa**

Portuguese Association of Geologists

The Portuguese Association of Geologists was established in 1976. It is a socio-professional association and a non-profit organisation that brings together professionals of geology who work in diverse fields within the Earth Sciences.

More information: ***http://www.apgeologos.pt*** and ***http://apgeologos.wordpress.com***

Visit us on Facebook: ***https://www.facebook.com/apgeologos/***

During the last year (2015), APG (Portuguese Association of Geologists) organised several initiatives aimed to promote geology to society.

Seminar "Geology on the Route of the Vineyard and Wine in the Region of Setúbal"

This Seminar, organised with the collaboration of the Earth Sciences Department (Universidade Nova de Lisboa), Casa da Baía de Setúbal and the Municipality of Setúbal, was held from March 27th to March 29th in Setúbal. It included a geo-wine-tour cruise, wine tasting, visits to some cellars, regional products exhibitions, conferences, debates, and field trips, during which the participants had the possibility to get to know the rich geological heritage of Setúbal. This seminar was aimed at all those interested in the issues that were addressed and it was also included in the APG Teachers Training Plan. All places were filled.

APG Day & 7th Annual Meeting

The 2015 APG Day & 7th Annual Meeting was held in Lisbon on April 30th. This event included the APG Annual Ordinary General Assembly, as well as the special conference ***"Reflections on 50 years of activity of a geologist"*** by our colleague and associate Miguel Ramalho.

APG Teachers Training Plan (2015)

During 2015 APG organised some training courses integrated in the APG Teachers Training Plan. Besides the seminar mentioned above, two more training courses were organised and again all vacancies were filled:

- "***The Region of Peniche as a Laboratory for th e Study of Geosciences (2nd Edition)"*** carried out in Peniche from May 29th to May 30th with the support of the Centre-West Schools Association Training Centre and the Secondary School of Peniche, and
- ***XXXV Update Course for Geosciences Teachers: "One Earth, Several Views"*** held in Estremoz on October 17th and 18th with the collaboration of the Science Centre of Estremoz and the support of Évora University and the Earth Sciences Institute.

5th APG Annual Meeting "Geology to Society: Challenges of the Future" and Training Courses

Last December (11th) APG organised the 5th APG Annual Meeting. This Geosciences professional annual event aims to increase public awareness on the importance of geology to the sustainable development of modern society. Being the single most important geosciences professional event in Portugal, this conference provides an open forum where participants are able to share new views and challenges on each year's theme.

The conference receives active participation by national government officials, academics and financial and industrial development experts, as well as students, teachers, technical professionals and other specialists of several fields in the Geosciences.

In the two days prior to the Annual Meeting (December 9th and 10th) two training courses were held , endorsed by the European Federation of Geologists: "From Space to Field: Applying new technologies in structural geology cartography" and "Geo-environmental rehabilitation in urban and mining areas".

Geoconservation Award

Every year the ProGEO Portuguese Group awards the prize "Geoconservation Award" to the municipality that best tried to implement a geoconservation project. This award is a way to promote geological heritage in Portugal. In 2015 the prize was awarded to the Municipality of Lisbon for its work in the conservation of the city's geological heritage. APG is part of the jury.

Summer with Ciência Viva

From July 15th to September 15th the scientific initiative "Summer with *Ciência Viva*" takes place, promoted by *Ciência Viva* – the National Agency for the Scientific and Technological Culture. Every year, participants of all ages can choose from hundreds of science and technology dissemination activities throughout the country in the company of experts from scientific institutions, associations, *Ciência Viva* centres, municipalities and companies. APG carries out various scientific activities within this programme.

In 2016 APG will continue to develop its activities to promote geology to society. The ***2nd Edition of the XXXV Update Course for Geosciences Teachers: "One Earth, Several Views"*** was held in Estremoz on January 9th and 10th and, as had happened in the first edition, all places were filled. The next ***APG Day & 8th Annual Meeting*** took place in Lisbon on March 11th and the new edition of the Geology and Wine Seminar ***"Geology on the Route of the Vineyard and Wine in the Alto Douro Wine Region"*** was held in Peso da Régua from April 1st to April 3rd. As part of the celebration of its 40th anniversary, APG will organise the EFG Workshop ***"The importance of geological knowledge for sustainable land use"*** and the EFG Summer Council Meeting. This annual event will be held in Lisbon from May 19th to May 22nd. The 3rd edition of ***"The Region of Peniche as a Laboratory for the Study of Geosciences"*** training course will take place on the 3rd and 4th of June. In November, APG will organise the ***6th APG Annual Meeting***, which will include the KINDRA National Workshop.

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News corner:
Compiled by Isabel Fernández Fuentes and Anita Stein, EFG Office

Endorsed training courses

EFG's training course endorsement programme is a free service with benefits to both course providers and EurGeol title holders. Applications are welcomed from the providers of short training courses, seminars, workshops, etc. Course endorsement will raise your company's profile and foster recognition within the European and international geoscience community. To apply for endorsement of your event(s) please download the application form and return it to ***info.efg@eurogeologists.eu***. A decision will be made within a few weeks following the receipt of your application. Endorsement is valid for three years, subject to receipt of satisfactory feedback from EurGeol title holders.
More information: ***http://eurogeologists.eu/training/***

Horizon 2020 projects

Horizon 2020 is the biggest EU Research and Innovation programme ever, with nearly €80 billion of funding available to secure Europe's global competitiveness in the period 2014-2020. From the beginning of 2015 the Federation was already involved in four Horizon 2020 projects: INTRAW, KINDRA, MINATURA2020 and ¡VAMOS!.

Three new projects started at the beginning of 2016: UNEXMIN, CHPM2030 and MICA.

INTRAW

642130 - INTRAW
International cooperation on Raw materials
START DATE: 1 February 2015
DURATION: 36 MONTHS

INTRAW, which started in February 2015, aims to map best practices and develop new cooperation opportunities related to raw materials between the EU and technologically advanced countries (Australia, Canada, Japan, South Africa and the United States) in response to similar global challenges. The outcome of the mapping and knowledge transfer activities conducted in the first two years of the project will be used as a baseline to set up and launch the European Union's International Observatory for Raw Materials as a permanent raw materials knowledge management body.

The European Federation of Geologists (EFG) is the coordinator of a consortium of 15 partners from different countries including Australia, the United States and South Africa. Most of EFG's members are also part of the consortium as EFG Linked Third Parties.

In February 2016 the consortium officially launched a set of reports analysing the contextual environment of the project's five "Reference Countries". The reports present the countries' historical economic development during the 20th and 21st centuries in general, and in relation to primary raw materials management in particular. The launch of these reports was actively promoted in March and April through a press release and social media: ***http:/intraw.eu/publications***.

The publication of three transactional reports on Research & Innovation, Education & Outreach and Industry & Trade is currently in preparation and scheduled for September.
For more information: ***www.intraw.eu***

MINATURA2020

642139 - MINATURA 2020
Developing a concept for a European minerals deposit framework
START DATE: 1 February 2015
DURATION: 36 MONTHS

MINATURA2020 was launched in February 2015 as a response to social needs to safeguard mineral deposits of public importance for the future. The overall objective of this three-year project is to develop a concept and methodology for the definition and subsequent protection of "Mineral Deposits of Public Importance" (MDoPI) in order to ensure their best use in the future.

EFG is involved in the establishment of the Council of Stakeholders and leads the Work Package on Dissemination.

A survey on "Mineral Deposits of Public Importance" aims currently to collect information in order to achieve a Pan-European approach on the topic of safeguarding non-energy minerals. The survey is accessible after registration. Detailed instructions are available on the website.

Several stakeholder workshops were organised at national level in the participating countries. More events will follow in the coming months. Full information is available in the news section and the events calendar of the project's website.
More information: ***www.minatura2020.eu***

KINDRA

642047 - KINDRA
Knowledge Inventory for Hydrogeology Research
START DATE: 1 January 2015
DURATION: 36 MONTHS

Groundwater and hydrogeology-related research activities cover a wide spectrum of research areas at EU and national levels. However, groundwater issues are quite often either ignored or considered only in insufficient detail and separated from the associated surface water bodies, despite groundwater's critical importance as renewable, high-quality, naturally protected (but still vulnerable) resource that has significant impacts on both surface water bodies and ecosystems. The EU-funded KINDRA project seeks to take stock of our current knowledge of hydrogeology through an inventory of research results, activities, projects and programmes.

EFG is the leader on the data collection and processing to carry out an EU-wide assessment of existing practical and scientific knowledge (using the developed HRC-SYS) focussing on EU, national, regional, international and EU-third party scientific activities. This assessment will be implemented with the help of the national members of EFG. EFG is also involved in the dissemination activity. Most of EFG's members are also part of the consortium as EFG third parties.

With the participation of experts from 20 European countries, representing EFG's Linked Third Parties (National Associations), an orientation workshop was organised in Seville in February 2016. The aim of the workshop was to explain the project goals in great detail to the experts who will participate in data collection on groundwater research at a national level and populate the European Inventory for Groundwater Research (EIGR) throughout the year. During the workshop the EIGR was tested and detailed guidelines for populating the EIGR have been provided. The response of the participants was very positive and valuable suggestions were given to improve the EIGR's user functionalities.
More information: ***www.kindraproject.eu***

¡VAMOS!

642477 - VAMOS
¡Viable and Alternative Mine Operating System!
START DATE: 1 February 2015
DURATION: 42 MONTHS

The aim of the EU-funded ¡VAMOS! (Viable Alternative Mine Operating System) project is to design and build a robotic, underwater mining prototype with associated launch and recovery equipment, which will be used to perform field tests at four EU mine sites. The project consortium passed a major milestone in September 2015 with the successful delivery of conceptual design plans of the prototype and all associated equipment.

EFG supports the project through stakeholder engagement and dissemination activities.

Site visits to the 4 pre-trial locations were completed in April. An evaluation of all acquired data will be taken into account in the selection process of test sites, which are due to take place from mid-2017. The locally available knowledge and documentation about each site's exploitation history and the nearby availability of associated facilities for the test campaign will be relevant to the selection process.

On 21 April EFG organised a workshop in São Domingos, a mining village founded to support the exploitation of a copper-zinc mine in the Iberian Pyrite Belt in the 19th century. The mine closed in the 1960s and is now abandoned. The aim of this workshop was to bring together a wide group of local and regional stakeholders with interests in the Iberian Pyrite Belt, and to collect their views and insight on possible development scenarios linked to the reopening of some of the abandoned mines in the future. Public participation and public discussion were encouraged and nearly 50 people, representing regional authorities and local stakeholders, attended the workshop. The information collected is being processed and will be incorporated in the project deliverables.
More information: ***http://vamos-project.eu***

UNEXMIN

690008 - UNEXMIN
Autonomous Underwater Explorer for Flooded Mines
START DATE: 1 February 2016
DURATION: 45 MONTHS

Thirteen organisations from seven countries across Europe are collaborating in this ambitious project to develop a submersible robotic system for surveying and exploration of flooded mines. The €5M project, funded by the European Union's Horizon 2020 research programme, will include the development of a Robotic Explorer (UX-1) for autonomous 3D mine mapping to gather valuable geological information that cannot be obtained in any other way: in general the mines will be too deep and dangerous for access by human divers.

Some of EFG's national associations participate in this project as Linked Third Parties and support the consortium through data collection for the inventory of flooded mines. EFG also supports the Work Package on dissemination and EFG's Third Parties will disseminate the project results at national level in web portals, newsletters, conferences, workshops, educational activities, exhibitions or by any other relevant means.

The project's kick-off meeting was held in Miskolc, Hungary, on 18 and 19 February 2016.
More information: ***www.unexmin.eu***

CHPM2030

654100 - CHPM
Combined Heat, Power and Metal extraction from ultra-deep ore bodies
START DATE: 1 January 2016
DURATION: 42 MONTHS

The CHPM2030 project aims to develop a novel, pilot level technology which combines geothermal resource development, minerals extraction and electro-metallurgy in a single interlinked process. In order to improve the economics of geothermal energy production the project will investigate possible technologies for manipulating metal-bearing geological formations with high geothermal potential at a depth of 3-4 km in order to make the co-production of energy and metals possible and that coud be optimised according to the market demands in the future. Led by the University of Miskolc, the project will be implemented through the cooperation of 12 partners from 10 European countries.

EFG supports the activities for the CHPM2030 methodology framework definition (WP1), particularly the European data integration and evaluation: EFG's Linked Third Parties (LTP) will collect publicly available data at national level on deep drilling programmes, geophysical and geochemical explorations and any kind of geoscientific data related to the potential deep metal enrichments. They will also collect data on the national geothermal potential. Guidelines/templates for data collection will be provided by EFG.

During the second year, EFG will support the road mapping and preparation for Pilots (WP6), European Outlook. EFG's Linked Third Parties will assess the geological data on suitable ore-bearing formations and geothermal projects collected in WP1, in relation with the potential application of the CHPM technology. This work will combine these data with the outcomes of the most recent predictive metallogenic models. Only existing datasets will be utilised, no new surveys will be carried out.

EFG also leads the Work Package on dissemination.

The kick-off meeting of took place in Miskolc, Hungary, on 28 and 29 January 2016. The meeting was attended by partners from 9 European countries representing 11 different universities, associations and companies. The main objective of the meeting was to present the project plan in more detail, with a clear time frame, and to clarify the role of each partner in relation to the different work packages.

The tenth edition of GeoTHERM, Europe's biggest meeting place for geothermal energy, took place on 25 and 26 February 2016 at Offenburg, Germany. EFG President Vitor Correia delivered a keynote speech about the importance of geothermal energy as a clean energy source in the future.
More information will soon be available at: ***http://chpm2030.eu***

MICA

689648 - MICA
Mineral Intelligence Capacity Analysis
START DATE: 1 December 2015
DURATION: 26 MONTHS

The MICA project brings together experts from a wide range of disciplines in order to ensure that Raw Materials Information is collected, collated, stored and made accessible in the most useful way in order to correspond to stakeholder needs. Hence, the goal for MICA is to provide stakeholders with the best possible information, in a seamless and flexible way using an ontology-based platform, the European Union Raw Materials Intelligence Capacity Platform (EU-RMICP). To accomplish this goal, MICA will assess sources of relevant data and information and conduct analyses of appropriate methods and tools in order to provide guidelines and recommendations.

EFG supports the Work Package on communication, outreach and linkages. In collaboration with EuroGeoSurveys, EFG will be involved in the development of the communication strategy, the engagement with geosciences data providers, and professionals and public outreach.

The MICA partners and Linked Third Parties gathered together for the first time at the project's kick-off meeting held in Copenhagen on 2-4 February 2016.
More information: ***http://mica-project.eu***

EFG Medal of Merit

The 2016 EFG Medal of Merit will be awarded to the illustrious Portuguese professor of hydrogeology José Martins Carvalho during the EFG Council Meeting in Lisbon, Portugal, on 21 May 2016. José was the Portuguese delegate to the EFG during its conceptual years, from 1978 to 1980 and then during its formative years, from 1980 to 1989. He was instrumental in helping to build the basic structure of the EFG, through its statutes, regulations, code of deontology (ethics), etc. In particular he was an active and dedicated Secretary-Treasurer of the Federation from 1983 to 1986.

José gives outstanding support for professional geology throughout Europe and beyond. With his quiet authority and leadership he is an example to us all. On a personal basis he is not only very good company but he is also a superb "Ambassador" for the profession, showing integrity and loyalty to his fellow geologists. In 2015 José's many achievements were marked with the publication of a thematic issue of *Environmental Earth Science* in his honour.

EAGE/EFG Photo Contest 2016

EFG and the European Association of Geoscientists and Engineers (EAGE) are again jointly organising their photo contest 'Geoscientists at work'. Members of EFG and EAGE were invited to submit their photos in the following sub-categories:

1. Education & training
2. Landscapes & environment
3. Fieldwork
4. Energy

An impressive number of photos was submitted by the deadline for participation (14 March 2016) and a vote determined the 12 most popular photos, which will be shown in a travelling exhibition that visits several EAGE and EFG events throughout Europe.

More information: ***http://houseofgeoscience.org/photocontest***

Book review:

Soil and Rock Description in Engineering Practice

Vanja Bisevac, European Federation of Geologists

Soil and Rock Description in Engineering Practice – 2nd edition
by David Norbury
Published by: Whittles Publishing, Dunbeath, Caithness KW6 6EG, Scotland, UK, 308 pp, 2016
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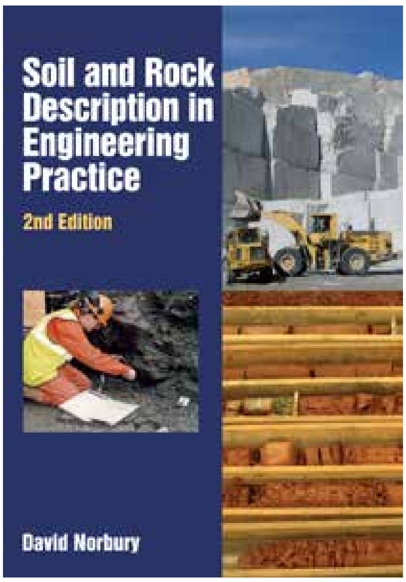

In ground investigation, the description of soils and rocks in engineering practice forms a major input to the field log. Practical guidance is provided for those in the field carrying out engineering geological logging of soil and rock samples and exposures. Soil and Rock Description in Engineering Practice enables the practitioner to record and present features of the ground from the exposure in such a way as to convey a field presence to subsequent users of the data.

This is a revised and updated edition of the highly successful first edition. In the intervening period the procedures used in the description of soils and rocks have continued to develop and evolve and this new edition incorporates changes in the national and international standards, BS 5930:2015 and EN ISO 14688 and 14689, and makes close comparison with US practice in description (ASTM D2488) and classification (ASTM D2487).

In addition, changes in definitions, naming procedures, and new terms are all included and explained. More detailed guidance is given for several procedures, including identification of minerals in the process of naming rocks, comparisons of terminology between engineering geology and the other geosciences, and alignment of the classification approach to that proposed for earthworks in line with EN 16907.

The book continues to provide invaluable practical guidance in carrying out engineering geological logging of soil and rock samples and exposures in the field. The systematic and codified approach are laid out in detail to ensure that the defined descriptors are used in a consistent format, rendering mistakes less likely and the necessary communication from field to design more successful.

The procedures, techniques and tips contained within this book continue to serve and guide young practitioners learning their craft, but also their seniors and mentors, including responsible experts who sign off the logs and who report on behalf of their company. More than ever, the need to be aware of current practices in order to avoid costly mistakes is paramount.

To conclude, this a very thorough book and is well-presented with clear tables, helpful thumbnail photographs and figures and text boxes containing very useful tips and example description. It can be set as a reference book as well as endless source of information. Additionally, it will help both practitioners and their colleagues and clients benefit from objective and consistent descriptions. This book is essential reading for anyone involved in the technical aspects of site characterisation.

Brussels, 5 April 2016
VB

Submission of articles to European Geologist Journal

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The Editorial Board of the European Geologist journal welcomes article proposals in line with the specific topic agreed on by the EFG Council. The call for articles is published twice a year in December and June along with the publication of the previous issue.
The European Geologist journal publishes feature articles covering all branches of geosciences. EGJ furthermore publishes book reviews, interviews carried out with geoscientists for the section 'Professional profiles' and news relevant to the geological profession. The articles are peer reviewed and also reviewed by a native English speaker.
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