Geological criteria to the 3D delimitation of groundwater bodies (GWB) in the hydrographic district of Sardinia

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ABSTRACT

The Water Framework Directive 2000/60/EC (WFD), establishing a framework for Community action in the field of water, has introduced for all Member States the obligations relating to the identification of surface and groundwater bodies and their monitoring, classification and definition of programs of measures to achieve a good status of all water bodies. In compliance with this statement, the River Basin Management Plan of Sardinia (Regione Sardegna, 2015) has identified and delimited 114 groundwater bodies (GWB). Main criteria were the identification of geological boundaries at the scale of 1:200,000, hydrogeological divides, analysis of pressures, and chemical status of groundwater.

In order to have a better knowledge of groundwater bodies boundaries, a more detailed delineation and characterization is in progress. As a first step of delineation the geological map of Sardinia at the 1:25,000 scale was used. Considering that the aim of this map was not for hydrogeological purpose, its reinterpretation was mandatory.

Every geological context needs in-depth knowledges to describe and model it properly. A further hydrogeological analysis can allow new interpretation of existing model according to the most recent methodologies developed. Each GWB required a different investigation specific approach. For example, incoherent recent deposits (gravels, sands, silts, clays, etc.) hosting groundwater bodies are characterized by porous aquifers types. Thus, necessary to consider the geometric relationships between stratigraphic units and the depositional environment provides important information on the lateral variation of hydrogeological features. Otherwise, the groundwater bodies hosted in crystalline rocks show continuous lithological characteristics for wide zone, but the primary relationships with neighboring units are often modified by tectonics (Feroni Cerrina et al., 2008).

The geological, hydrogeological and hydrogeochemical knowledge of GWBs becomes necessary to understand the quantitative state (extension and thickness of the area, yield, specific storage) and qualitative state (chemical state) for the correct delimitation of the GWB.

Keywords: geology, CIS, groundwater, Sardinia

METHODS

The methodology for the definition of GWBs, based on the criteria of the WFD guidelines and by the Italian Legislative Decree 30/09, consists in the identification of aquifers on geological and hydrogeological basis and then the identification of groundwater bodies taking into account main changes in anthropogenic pressures and changes in quantitative/chemical status. This process has been divided into three main phases:

1. Input, for data collection;
2. Processing, for expert data control and interpretation;
3. Output, for the delimitation of the GWBs and the extraction of their geographical and geometrical attributes.

The basis for the aquifers/GWBs re-measurement operation has provided for an initial phase, during which the limits were extracted from the official geological map of Sardinia in scale 1:25,000 (http://www.sardegnageoportale.it/). Then the limits between aquifers/GWBs have been updated on the base of geological criteria identified at the new scale of representation. In this phase, especially where overlapping aquifers are present, the limits were defined and validated basing on the geological information of the terrain and the stratigraphic data, obtained from the recent and historical cartography, and the control of the available stratigraphic logs.
The study has been done in ESRI ArcGIS environment.

RESULTS

The methodological approach provided a 3D reconstruction of the groundwater bodies (GWB), considering all the geological features (sedimentological, stratigraphic, tectonic, etc.) that shaped them and that can separate one from each other. In particular, to define a 3D model of the Plio-Quaternary GWBs in coastal plains the main effort was made in relating each sedimentary body with the proper depositional environment. In this way, the lithological sequence detected in well logs or geophysical logs can be extended laterally considering them as depositional sequences. This allowed to reconstruct the geometries of the GWB in a reliable way in space and time. Further, one of the main challenges in studying coastal plains is to estimate the stratigraphic thickness. In this case, when well logs were not available, the GWB thickness of recent deposits along the river branches has been inferred taking into account the slope geometry. Some lithostratigraphic units of reduced thickness were excluded after a case-by-case analysis. They, while exercising a hydrogeological function, do not constitute a significant permanent resource, since are saturated for short periods of the year. Moreover, the occurrence of the water intakes allowed to identify buried GWB. Less important than for other kind of GWB are the occurrence of tectonic structures, considering the recent geological evolution of Sardinia. Finally, construction of detailed geological sections was useful for the 3D reconstruction of GWB and to validate the final model.

References

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