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An evaluation on sedimentary facies, hydrochemistry condition and degree of consolidation in travertine deposits of the Nodushan Spring, northwestern of Yazd

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Abstract
This study tries to evaluate the geological properties of a travertine spring and its related deposits. The identification of sedimentary facies of springs could be applied as a method to distinguish the type of travertine springs. Therefore in this study, that method has been used for the determination of the type of the spring. Results obtained from facies analysis reveal 13 sedimentary facies that could be categorized into two groups including organic facies which contain five facies and abiotic facies containing eight facies. These facies show the character of hydrothermal spring and set the spring in the thermogenic group. The chemical composition analysis of the spring water represents the facies of NaCl, Na-Ca-SO_4-Cl can be considered to be precise chemical facies. The presence of calcium and sulfate as the second most frequent ions, after sodium and chloride, may initially indicates the existence of gypsum or anhydrite deposits in this area. On the other hand, given the absence of sulfate-bearing sediments in this region, it can be concluded that the interaction of water and magmatic systems was the most important source of sulfate in the spring water. Based on the rock mechanical properties of the travertine, it was revealed that with increasing age of the sediments their consolidation degree increases. The hardness of sediments shows an increasing trend by increasing distance from the spring vent.
Keywords: Travertine, Sedimentary facies, Thermogene, Hydrochemistry, Yazd.

Introduction

Travertine is one of the most well-known continental carbonate rocks, which has been highly regarded for its commercial-decorative quality. Travertine is made up of a variety of sediments that are formed through two main processes: first, carbonate sediments originating from running water that is lithified during sedimentation (abiotic crystals and facies caused by microbial activity). Second, sediments that were deposited like marine carbonates in an aquatic setting such as lakes, swamps, streams, and temporary ponds. To eliminate the complexities of travertines, a classification on hot spring sediments has been proposed to identify the relationships between sedimentary processes and fabrics of sediments. Numerous studies have considered the influence of water chemistry, as well as the dynamics of flow at the source of the springs, on the sedimentation mechanism. Underground water chemistry is one of the essential parameters for evaluating the environmental characteristics of each region. This paper aims to investigate the sedimentary facies of travertine deposits of the Nodushan Spring in the northwest of Yazd in central Iran. Moreover, the relationships between these facies and the mechanism of their formation based on the facies, hydrochemistry condition, and mechanical properties are examined.

Material & Methods

According to the Aqda geological map (1:100,000), the location of the study area was determined and geological features were considered. A total of 42 samples were collected and the necessary field photos from macroscopic features of the region were captured. After that, thin sections of the samples were studied by a polarizing microscope. In this study, three samples of water collected from the travertine ponds of this spring have been analyzed for hydrochemical properties. Various physicochemical parameters have been analyzed, including calcium (Ca), sodium (Na), potassium (K), magnesium (Mg), ammonium (NH_4), bicarbonate (HCO_3), sulfate (SO_4), chloride (Cl), fluoride (F), nitrate (NO_3), pH, temperature, turbidity, as well as total alkalinity, hardness and dissolved solids (TDS). The degree of consolidation of the samples was also measured by Schmidt hammer to investigate its relationship with travertine fabrics.

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Discussion of Results & Conclusions

The deposition of carbonate sediments in the form of travertine in hot springs reflects the characteristics of a tectonic-geothermal system. Of course, sedimentation is not only affected by water temperature, but also by the saturation of calcium, flow rate, water flow mechanics, as well as the presence of sulfur compounds, which affect the environmental conditions of the environment. Facies analysis indicates that 13 sedimentary facies could be categorized in two groups: organic facies which contain five facies (clotted micrite, stromatolite bindstone, microbial rafts, oncoid facies, and dendritic shrubs) and abiotic facies comprise eight facies (crystalline crusts, fan-ray crystals, feather-like crystals, coated bubbles, spheroid facies, and needle-shaped shrubs). These facies show the character of hydrothermal spring and put the spring in the thermogenic group. It generally seems that crystalline facies have been largely influenced by abiotic sedimentation, while laminar facies were formed under the influence of microbial activity related to hot springs. Rapid sedimentation rates lead to the dominance of abiotic processes, while slow rates create more microbial activities that are effective in sedimentation processes.

The chemical composition analysis of the spring water represents the facies of NaCl, Na-Ca-SO_4-Cl can be considered to be precise chemical facies. The presence of calcium and sulfate as the second most frequent ions - after sodium and chloride - it may initially indicate the presence of gypsum or anhydrite sediments in this area. On the other hand, given the absence of sulfate-bearing sediments in this region, it can be concluded that the interaction of water and magmatic systems is the most important source of sulfate in spring water. Also, changes in Na/(Na + Ca) and Cl/(Cl + HCO_3) relative to the amount of TDS in the analyzed water sample show that the predominant process controlling the water quality of this spring is evaporative processes, which occurs as a result of direct connection of water with atmosphere after leaking from the spring.

Based on the mechanical properties of the travertine, it was revealed that with increasing age of the sediments their consolidation degree increased. The hardness of sediments shows an increasing trend by increasing distance from the spring vent. Moreover, it was found that major discontinuities observed in the wall of the valley not effective role in drainage of surface waters, so that formation of the sediments was directly related to the spring water.