

GOAL EDUCATIONAL RESOURCE

AUTHORS	Cristina Calheiros (University of Porto, Portugal), Nir Orion (Weizmann Institute of Science, Israel) & Clara Vasconcelos (University of Porto, Portugal)
TITLE OF THE CASE	Earth system nexus human interaction: a geoethical perspective
SHORT CASE DESCRIPTION	Paço de Calheiros is a manor house and farm involved in many activities. It is a special place where the water (hydrosphere), the soil (geosphere) and the local climate (the atmosphere and its close interactions with the geosphere) are very important. Geoethical dilemmas arise as the sustainability of this heritage may be in jeopardy.
KEYWORDS	Geoheritage; Georesources; Sustainability; Water cycle.
PRIOR KNOWLEDGE	Earth sub-systems; Geoheritage; Georesources; Holistic view of the Earth system.
AIM	Promotion of geoethical values (ethical, cultural and social) related to human interaction with the Earth system through reflection on georesources, geoheritage and the need for geoscientists to raise public awareness of their work.
OBJECTIVES	<ul style="list-style-type: none"> • To defend geoethical values to preserve the Earth system (social value). • To enhance the geological landscape by raising human aesthetic values like, for example, respect for the land that sustains our lives (cultural value). • To understand the need to strictly respect the natural systems and dynamics when designing interventions on the environment (ethical value). • To discover ways of protecting and enhancing geodiversity for the sustainable development of communities (ethical value). • To develop sustainable activities in order to ensure energy supply and natural resources for future generations (social value). • To explain the work of geoscientists to better preserve the Earth system (ethical value). • To bolster citizens' awareness of the work of geoscientists (social value). • To boost geoethical education in schools and in higher education (social value). • To raise citizens' awareness of geoethics (social value).

CASE

Paço de Calheiros is a 17th century manor house with a 13 ha farm located on a rural hilltop in the Lima Valley, in northern Portugal (fig.1). The house was built with local resources, essentially made from granite, and is classified as a Monument of National Interest. Its surroundings are classified as Historic Gardens by the Association of Historic Gardens of Portugal. It is now owned by the third Count of Calheiros. The family is historically connected to the foundation of Portugal, in 1143. The farm's main activities involve the management of: tourism, vineyards, wine production, small corn production, vegetable garden and a chestnut forest (fig.2).



Fig. 1 – Paço de Calheiros.



Fig. 2 – Example of activities at Paço de Calheiros: a) chestnut forest, b) vegetable garden, c) vineyards and corn production, d) tourism.

In a rural context, the management of water cycles is of the utmost importance, essential to the community's freshwater supply (for farming and other agricultural activities), as well as to ensure the water quality after its use. In this case, the wastewater from the main house is treated in a constructed wetland and reused for irrigation in the gardens. The amount of water required to meet the demand for food, energy, human uses and the ecosystem is associated to uncertainties regarding the impact of climate change. The heart of Paço de Calheiros farm is its freshwater spring. This phenomenon of the hydrosphere is a result of interactions between the geosphere and the atmosphere. The topographic height of this area, an outcome of the geosphere, influences the temperature of the

atmosphere and, therefore, the amount of precipitation (rainfall) in this granitic area. The geological forces have formed granite joints through which rainfall enters the unconfined aquifer and crosses its unsaturated area. As the water table is at a higher level than the unconfined aquifer, together with the slope inclination, the underground water appears at the surface of the farm as a spring (Fig.3).



Fig. 3 – Water spring.

A stream flows down the hill, a part of which passes through the farm (Fig.4). This is part of a decades-old agreement, establishing the farm's right to a certain amount of water. Accordingly, the records show that the farm would always be entitled to enough water to push an orange downhill (Fig.5).



Fig. 4 – (a) stream passing near the farm, (b) waterway flowing through the farm.

The type and the quality of this farm's wine - *vinho verde* (the name literally means "green wine" but is translated as "young wine" because it is bottled 3-6 months after the grapes are harvested) is also directly related to the interactions between Earth systems (Fig.6). The water (hydrosphere), the soil (geosphere) and the climate in this area (the atmosphere and its close interactions with the geosphere) are favorable to vines that produce a light, fresh wine, as in the case of this farm. Many of the small farmers usually train their vines high off the ground (up trees, fences, and even telephone poles) in order to cultivate vegetable crops below them, regarded as a supplementary food source for their families (Fig.7). Thus, the farm is part of the socio-cultural heritage of this region and preserves its geological heritage (landscape).



Fig. 5 – Water pushing an orange in the farm’s canals.



Fig. 6 – Vineyards at Paço de Calheiros.



Fig. 7 – Food production under the vines.

The Count of Calheiros was walking through the farm with his grandson and questions arose when reflecting on the surroundings and geologic site. The grandson started thinking about the future of the farm and asked some questions.

QUESTIONS

1. What would happen if the spring that provides the house with water should run dry?
2. If there were a decision to divert the part of the stream the farm has a right to (for example, to support building a factory that would bring jobs to the village inhabitants), what would be the impact on wine production and organic farming?

	<ol style="list-style-type: none">3. If a road were to be built across the farm (for example, to improve access to the main village), to what extent would we be able to preserve the geological heritage?4. What are the consequences of not informing the owners of these houses and the village inhabitants about the area's geology?5. How can we avoid the risk of not preserving this geoheritage site?
PROCEDURE	<ol style="list-style-type: none">1. Watch the video (https://youtu.be/TMM2XgHbc3w) and the video (https://youtu.be/QzINvZ4HN4A) and think about possible answers to the questions.2. Read the following articles, "Peppoloni, & Di Capua (2017)" (https://goal-erasmus.eu/wp-content/uploads/2019/02/GEOETHICS-ETHICAL-SOCIAL-AND-CULTURAL-VALUES-IN-GEOSCIENCES-RESEARCH-AND-PRACTICE.pdf) and "Bobrowsky et al (2017)" (https://goal-erasmus.eu/wp-content/uploads/2018/10/Emerging_Field_Geoethics.pdf), and write down some Geoethical values that may be at risk in this site and which ones citizens should fight for in order to preserve this geoheritage. Think especially about the Geoethical values involved in preserving the water supply as well as the wine and agricultural production.3. Read the Agenda 2030 for Sustainable Development (https://www.un.org/sustainabledevelopment/development-agenda/) and try to relate the targets of the Agenda and the Geoethical values that can contribute to bolstering their fulfilment.
REFERENCES	<p>Bobrowsky, P., Cronin, V.S., Di Capua, G., Kieffer, S.W. & Peppoloni, S. (2017). The Emerging Field of Geoethics. In L.C. Gundersen (Ed.), <i>Scientific Integrity and Ethics with Applications to the Geosciences. Special Publication American Geophysical Union</i>. Hoboken: John Wiley and Sons, Inc.</p> <p>Peppoloni, S. & Di Capua, G. (2016). Geoethics: Ethical, social, and cultural values in geosciences research, practice, and education. In G. Wessel & J. Greenberg (Eds), <i>Geoscience for the Public Good and Global Development: Toward a Sustainable Future</i> (pp. 17-23). Geological Society of America. doi:10.1130/2016.2520(03)</p> <p>Peppoloni, S. & Di Capua, G. (2017). Geoethics: ethical, social and cultural implications in geosciences. <i>Annals of Geophysics</i>, 60, 1-8. doi:10.4401/ag-7473</p> <p>United Nations (2015). <i>Transforming our World: the 2030 Agenda for Sustainable Development (A/RES/70/1)</i>. Retrieved from: https://www.un.org/sustainabledevelopment/development-agenda/</p>