C1: Topography and hydrology monitoring

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CONTENT

1. INTRODUCTION

This section presents the work carried out and the results obtained in relation to Action 2 “Rill erosion survey”.

This action aimed to continue erosion monitoring in order to (1) measure the evolution of the rills network and identify erosion rates once the system has stabilised and (2) monitor the evolution of the abrupt GeoFluv ("herringbone") restoration, in case any treatment is necessary.

During the Life Tecmine period, the rill erosion was monitored, which is reported in the report “C. Monitoring of the Impact of the Project actions. Action C 1.1 Monitoring of topographic evolution and erosion rate”. This can be used as a reference document in order to interpretate the After Life results.

The After Life actions envisaged were as follows:

- Rills field-sampling once a year (2023 and 2024). Data analysis and reporting.
- Photographic monitoring of "herringbone" and erosion in GeoFluv Small and Large and Report (2023 and 2024).

2. RESULTS

2.1. Qualitative rills survey

The observations made in the units identified in the Tecmine report are presented. These are as follows:

- Eastern GeoFluv (=Conventional GeoFluv without tree holes): no rill networks had been developed in 2021. No rills have been found in 2023 either, as shown in the figure 1.
- Western GeoFluv, “Conventional GeoFluv with tree holes”: Rill network was underdeveloped in 2021 (rill density: 0.16 m/m^2). Photographs and field observations indicate that the rills have become non-functional in some areas as vegetation has developed. No new rills have been developed. See figures 2 and 3.
- In Western GeoFluv, the restored zone with overburden substrate evolved from 0.24 to 0.32 m/m2 in rill density between 2020 and 2021. These were densities well below the 0.60-0.70 m/m2 that are considered the threshold above which erosion prevents vegetation development in restored mining areas very similar to Fortuna quarry (Moreno de las Heras *et al*, 2009; 2011). Observations made in December 2023 indicate a stabilisation of the erosive forms. The poor development of vegetation is due to the poor quality of the soil. See figure 4.

Overall, the observations made in 2023 point towards no increase in the number of rills and no increase in the size of rills. This is what we expected since Hanckok *et al*. (2016) showed how erosion rates in restored mining areas reach the highest values in the first year after restoration -when rill networks are formed- and decrease exponentially until stabilizing in the fourth year.

2.2. Qualitative monitoring of the abrupt GeoFluv ("herringbone")

The most critical area from an erosion point of view is the “Abrupt Geomorphological Restoration area” where, on the one hand, the upstream erosion in the main channel of "herringbone" is really important, affecting 77.4% of the length of the channel in 2021. And on the other hand, rill network density is very high, closed to the maximum tolerable rates for plant community can develop (0.60-0.70 m/m^2). This is why this area needs specific monitoring.

Figure 5 shows the evolution of the erosive forms over the years with images from 09.10.2019; 07.02.2020; 17.03.2021; 11.02.22 and 06.12.23. After the formation of the first drainage network and rills in 2019, a significant growth of the main channel and rills is observed in 2020 (tropical storm "Gloria" occurred in 19-21.01.2020). Erosion actively progressed in 2021 (storm "Filomena" occurred in 05.01.2021). In 2022, no major changes are observed. However, in the last year (2023) there is a widening of the main channel by side walls falling. No conclusions can be drawn on the rills, which will be measured quantitatively in 2024.

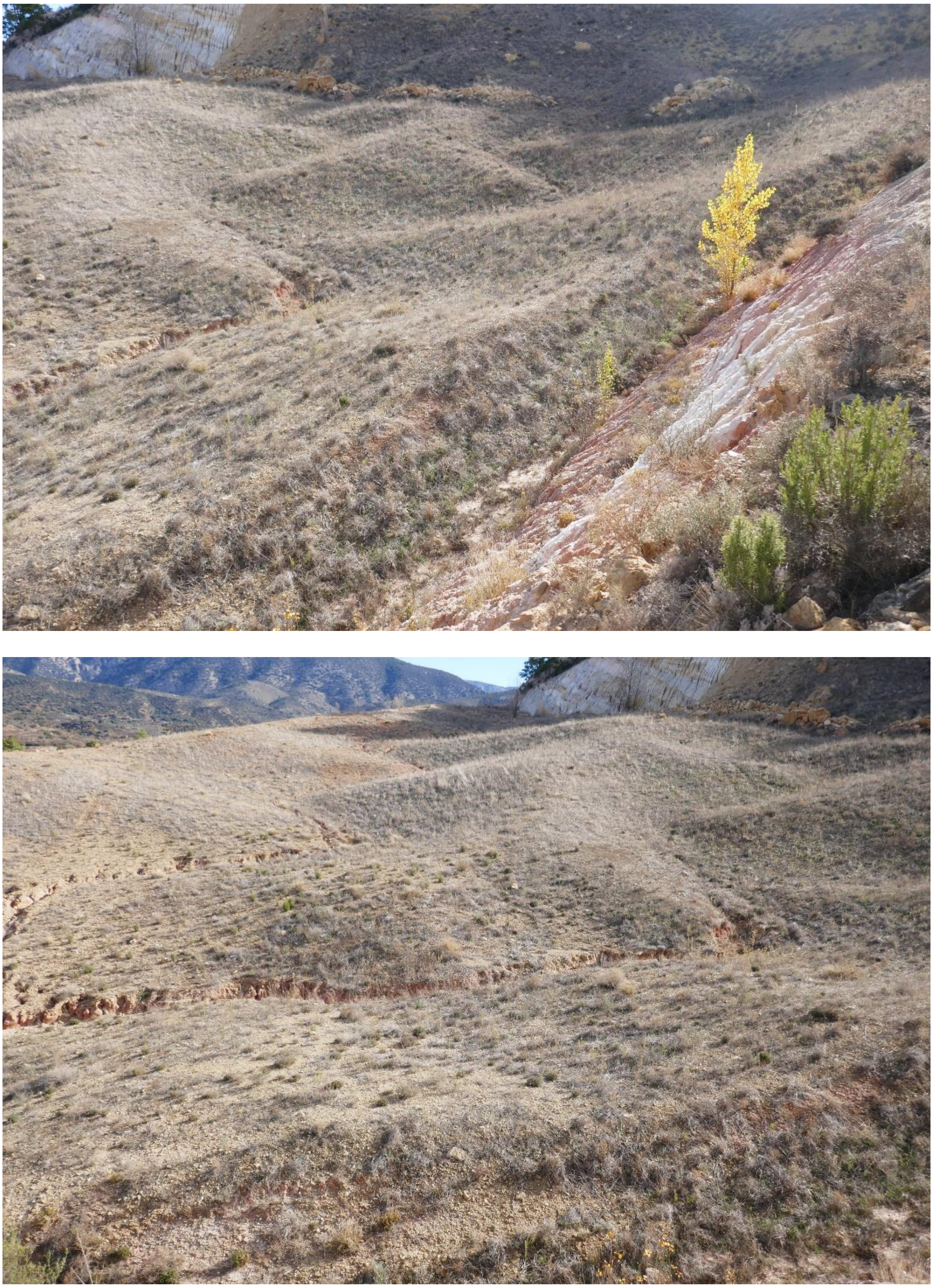

Figure 1. Panoramic view of Eastern GeoFluv (=Conventional GeoFluv without tree holes) in 06.12.2023. No rill system has developed and vegetation is not limited by erosion. The photo above is of the western side and the photo below is of the eastern side.

Figure 2. Panoramic view of Western GeoFluv "Conventional GeoFluv with tree holes" in 06.12.2023. Photographs and field observations indicate that the rills have become non-functional in some areas as vegetation has developed. No new rills have been developed. The photograph above corresponds to the lower part of the basin and the one below to the upper part.

Figure 3. Detail of Western GeoFluv "Conventional GeoFluv with tree holes". This is the main constructed slope with concave and convex forms. Rills formed in 2019 (photograph above) are not visible in the photograph below (December 2023), covered by vegetation and no longer functional.

Figure 4. Western GeoFluv, the restored zone with overburden substrate. There is no difference in the number and size of the rills between the top photograph (February 2022) and the bottom photograph (December 2023). Rills density in 2022 was about 0.32 m/m2, below the 0.60-0.70 m/m2 that is considered the threshold above which erosion prevents vegetation development in restored mining areas very similar to Fortuna quarry (Moreno de las Heras *et al*, 2009; 2011). Observations made in December 2023 indicate a stabilisation of the erosive forms. The poor development of vegetation is due to the poor quality of the soil.

Figure 5. Evolution of the erosive forms in abrupt GeoFluv ("herringbone"). The images from top to bottom correspond to 09.10.2019; 07.02.2020; 17.03.2021; 11.02.22 and 06.12.23. The explanation of the erosive evolution can be found in the text.

3. CONCLUSIONS

The qualitative observations made on the network of rills throughout the restoration of the Fortuna quarry indicate a stabilisation of their evolution over time, as well as a compatibility with the development of vegetation. Quantitative measurements are expected in 2024 to corroborate this conclusion.

The evolution of erosional forms in the abrupt ("fishbone") GeoFluv is still active. This year has seen a widening of the main channel. Pending quantitative data on the rill network, no growth in the number and size of rills is apparent. In fact, there is more than 50% vegetation cover on most of the slopes in this area.

4. REFERENCES

Hancock, G. R., Crawter, D., Fityus, S. G., Chandler, J., Wells, T. 2008. The measurement and modelling of rill erosion at angle of repose slopes in mine spoil. Earth Surface Processes and Landforms 33:1006-1020. doi:10.1002/esp.1585

Moreno-de las Heras, M., L. Merino & J.M. Nicolau. 2009. Effect of vegetation cover on the hydrology of reclaimed mining soils under Mediterranean-Continental climate. Catena, 77: 39-47.

Moreno-de las Heras, M., T. Espigares, L. Merino-Martín & J.M. Nicolau. 2011. Water-related ecological impacts of rill erosion processes in Mediterranean-dry reclaimed slopes. Catena, 84: 114-124.