HYDROGEOLOGICAL PROCESSES AND STRUCTURE OF THE RIO TINTO MARS ANALOG: SOME INSIGHTS FOR MARS UNDERGROUND WATER FLUXES. D. Gómez-Ortiz[1], D. C. Fernández-Remolar[2], O. Prieto-Ballesteros[2], F. Gómez[2]. [1]ESCET-Área de Geología, Universidad Rey Juan Carlos, 28933 Móstoles, Madrid, Spain (david.gomez@urjc.es), [2]Centro de Astrobiología-INTA, 28850 Torrejón de Ardoz. Spain (fernandezrd@inta.es, prietobo@inta.es, gomezgf@inta.es)

Introduction: The Iberian Pyritic Belt (IPB) consists of a 250-km long geological unit included into the South-Portuguese geotectonical zone of the Iberian Peninsula. It is comprised by an acid volcano-sedimentary complex ranging in age from upper Devonian to Carboniferous where different metallic ores were formed in response to hydrotermalism and tectonic related to the Variscan Orogeny [1, 2]. Inside the IPB, the Rio Tinto area contains some of the largest world's massive sulfide deposits.

In Río Tinto, the interaction between groundwater and sulfide deposits and sulfide-free rocks provides geochemical processes controlling the geochemistry of both surface fluids and groundwater. The resulting waters are characterized by an acidic chemistry (pH mean value of 2.3), and high concentrations of sulfur and iron in solution, which control the formation of analogous mineral associations that have been recognized in Meridiani [3, 4, 5].

As Mars basement have intensively fractured by meteoritic and geological events, same geochemical reactions ending in the formation of sulfates and oxides that occur in the Río Tinto surface-subsurface system may have occurred in the Mars early environments.

To understand the processes that drive the mineral formation of sulfur and iron bearing phases, special attention has been paid to the aquifer located on Peña de Hierro, North of Rio Tinto, which are the headwaters that supply the acidic waters of Río Tinto,. Given that Peña de Hierro aquifer is mainly controlled by the recharge from rainwater through the present fault system, a tectonic and hydrogeological survey has been conducted in order to accurately characterize underground water fluxes of the aquifer.

Geological setting of Peña de Hierro aquifer: Peña de Hierro is located at the contact between two different tectonic units included inside the IPB, Concepcion Unit to the North and RioTinto-Nerva Unit to the South (Fig. 1). The first one is composed by materials belonging to the volcano-sedimentary complex, mainly shales acidic tuffs and volcanic materials, conforming a complex antycline verging SW. The second one is constituted by dark shales and greywackes defining a synclinory verging NE. A highly deformed thin unit of purple shales delineates the contact between both units, defined by the San Miguel-Minas del Castillo Shear Zone (SMCSZ). It corresponds to a 55-km long Shear Zone with a N110ºE trend and dipping 70º N. The SMCSZ exhibits a transport direction towards the S with a reverse-sinistral component. This structure causes the inversion of the stratigraphical units along the boundary between Concepcion and Nerva-Rio Tinto Units. The SMCSZ formed during the second phase of deformation associated to the Variscan Orogeny (Fig. 1) and corresponds to a transpressional ductile deformation with associated penetrative foliation [1, 2].

A Late-Variscan episode of deformation is responsible for the development of a conjugate strike-slip system of brittle fractures trending NNW-SSE (dextral) and NNE-SSW (sinistral) respectively. These fractures are extensively distributed all around the IPB and represents the transition form ductile transpressional deformation to a brittle transtensional event related to the collapse of the Variscan Orogen. Some of these fractures are older Variscan structures reactivated whereas some of them are neoformed.

Due to the absence of Post-Palaeozoic sediments, the existence of Alpine deformation has not been defined in the study area, although it cannot be disregarded that some of the reactivations and structures attributted to Late-Variscan deformation would partially correspond to the Alpine NW-SE compressional event.

Tectonic hydrogeological survey: In order to obtain an accurate design of the fracture pattern present at the Peña de Hierro and surrounding areas, a tectonic study has been carried out. It implies the compilation of the fractures mapped in previous works, as well as the analysis of QuickBird and Ikonos satellite imaginery together with the artifical shading of a Digital Elevation Model (DEM) from different lightning azimuths (0º, 45º and 90º).

A total of 153 lineaments (Fig. 1) have been obtained. Many of them correspond to mapped fractures and discontinuities, whereas some of them have not been previously described in the literature. A rose diagram has been constructed to analyse the spatial orientation of the lineaments (Fig. 2). As can be seen, three different orientations are outlined: ESE-WNW, NNE-SSW and NNW-SSE. They completely agree with the mean orientations of the Variscan (ESE-WNW ductile Shear Zones) and Late-Variscan (NNE-SSW and NNW-SSE strike slip faults) previously defined. The three fault systems clearly control the drainage pattern in the area and also serve to recharge the Peña de Hierro aquifer from rainwater and to control the under ground water fluxes. Moreover, some of the artesian springs that source the Rio Tinto river are linked to these fractures [6].

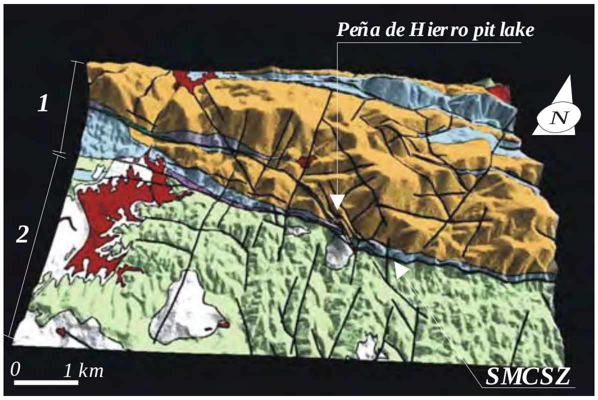

Figure 1. Geological map of the study area. 1: Concepcion Unit. 2: Rio Tinto Nerva Unit. The contact between both tectonic units correpsonds to the San Miguel-Minas del Castillo Shear Zone (SMCSZ). The lineaments mapped, corresponding to the fracture patern, are shown in black.

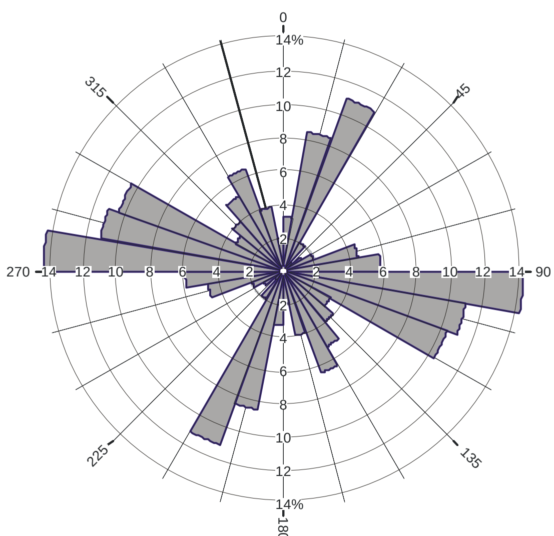

Figure 2. Rose diagram showing the three main orientations (ESE-WNW, NNE-SSW and NNW-SSE) of the fractures mapped in the area. The groundwater flow is controlled by these fracture systems.

In this sense, it has been mapped some N140ºE fractures that affect the Peña de Hierro mine pit. This pit has been filled with rainwater resulting in a lake with a great volume of dark red-wine colour, acidic water. The mapped fractures that intersect the pit lake also correspond with the location of some artesian springs exhibiting acidic waters of the same characteristics of the ones of Peña de hierro pit lake. This suggests that the fractures allow the groundwater flux from the pit lake through the shales corresponding to the Concepcion Unit, and finally feed the artesian springs.

The mean height of the water level in the pit lake is about 430-435 m a.s.l. Different boreholes performed for rock and fluid sampling in the Peña de Hierro aquifer show that the water table was located at 431 m a.s.l [6]. The close correpondence between the potential head between the water pit lake and the groundwater at the boreholes indicates that they are closely related and that a NW-SE groundwater flow should exist from the pit lake towards the boreholes along the N140ºE fractures. In addition to this, the intersection of the N140ºE fractures with the topographic surface generates artesian springs of acidic water located at about 410-430 m a.s.l. that evidences a groundwater flow directed from the pit lake towards the artesian springs along the fractures.

Implications for Mars undeground water fluxes: Fractures affecting to the Mars volcanic basement have probably played an essential role in storaging and transporting underground fluids through physichochemical grandients controlled by pH changes and oxidant concentration. In this sense, the Rio Tinto subsurface research provides some insights to understand the formation of sulfur bearing compounds observed in Meridiani [7-10] and many other regions of Mars. As observed in the Río Tinto aquifers, long-term subsurface sulfur storage in form of secondary sulfides can be a reasobable source for sulfates after oxidation by meteoric solutions provided by formation of acidifying and oxidizing compounds that are sourced in photochemical reactionships in the Noachian Mars atmosphere [6, 11].

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References: [1] Leistel J. M. et al. (1998) *Miner. Depos., 33*, 2–30. [2] Quesada C. (1998) *Miner. Depos., 33*, 31–40. [3] Fernández-Remolar, D. C. et al. (2005) *EPSL*, *240*, 149–167. [4] Fernández-Remolar D. C. et al. (2003) *JGR., 108(E7)*, 5080. [5] Stoker C. et al. (2004) *LPS XXXV*, Abstract #2025. [6] Fernández-Remolar D. C. et al. (under review) *Astrobiology* [6] Squyres S. W. et al. (2007) *LPSC XXXVIII*, this volume. [7] Bibring J. -P. et al. (2005), *Science*, *307*, 1576-1581. [8] Gendrin A. et al. (2005), *Science*, *307*, 1587-1591. [9] Arvidson R. E. et al. (2005), *Science*, *307*, 1591-1594. [10] Langevin Y. et al. (2005), *Science*, *307*, 1581-1584.[11] Fernández-Remolar et al. (2007), *XXXVIII LPSC*, this volume.