Revision of review 2 (anonymous)

Dear reviewer,

thank you very much for your interest and important comments. Our answers are included in the text of your review below.

1. GENERAL COMMENTS The manuscript appears not well finalized to the scope of the research due to the scarce integration of geochemical analyses with a consistent conceptual hydrogeological model of the area. This scarce connection limits the significance of the research just to the geochemical aspect. Following, some specific comments are reported that would finalize the manuscript more clearly to the scope of the research (title).

A: We agree that the hydrochemical work has to be connected with the hydrogeological framework. Thus we have revised the section 2.1 that describes the Hydrogeological Settings and included the evolution of hydrochemical facies in the Results section (see below).

2. SPECIFIC COMMENTS.

Section 2:

a) a classification of the climate type, by means of known system (e.g. Köppen-Geiger), would improve the description of the area;

b) the estimate of the mean annual actual evapotranspiration (e.g. by the Turc or Coutagne formulas) could give, together the mean annual rainfall, a general assessment of the groundwater recharge of the area.

A: The classification of climate has been considered in section 2, as follows:

2. Study area:

The study area is situated in the central portion of the state of Jalisco (Fig. 1). It belongs to the Lerma-Santiago river system, which drains into the Pacific Ocean. The climate in the study area according Köppen is a warm temperate with dry winter "Cwa" (Peel et al., 2007; Kottek , 2006). The National Water Commission reports an average annual temperature of 20.9°C and an average annual precipitation of 904 mm, occurring mostly between May and October. The mean annual evapotranspiration is 712 mm according to Turc formula (CONAGUA, 2010).

3. Section 2.1:

c) This chapter reveals some discrepancies respect the declared scope of the research (title):

a. regional geological setting and local hydrogeological setting should be described separately; in detail, the first aspect should be reduced respect to the present form, while the second one should be expanded.

b. hydrogeological description of the area is very scarce and limited to surficial aquifers only; moreover it does not correspond to what is shown in Figs 2 and 8;
c. hydrostratigraphic units should be described and characterized in terms of hydrogeological properties (e.g. type and degree of porosity and permeability, transmissivity, etc.);
d. data regarding groundwater levels and altitude of springs should be illustrated and interpreted in order to support a conceptual model of groundwater flow of the area.

A: We agree completely with your suggestion. We revised the local hydrogeological settings (2.1) in the manuscript: In the Description of the Study area we propose to extend the description of the hydrogeology of the study area as follows, and replaced Figures 2 and 8 with two new figures (Fig. 2 Hydrogeological settings, Fig. 3 Cross sections) for a better visualization:

The study area is located in the western portion of the Mexican Volcanic Belt (MVB), a 1000 km-long volcanic arc that crosses central Mexico in E–W direction from the Pacific to the Atlantic Ocean. The MVB originated in the Late Miocene in response to the subduction of the Cocos and Rivera plates below the North American plate along the Middle America Trench. The belt has a composition of intermediate to silicic rocks (Alva-Valdivia et al., 2000). The western end of the MVB defines the fault bounded crustal Jalisco Block (Ferrari et al., 2007; Valencia et al., 2013). The northern and eastern boundaries of this block consist of asymmetric continental rifts formed by tilted blocks with escarpments between 800 and 1000m (Zárate-del Valle and Simoneit, 2005); the Tepic–Zacoalco Rift to the north runs in an NW–SE direction, and the Colima Rift to the east runs in an N–S direction; these rifts join the E–W oriented Citala or Chapala Rift in what is known as the Jalisco Triple Junction located 60 km SSW of the city of Guadalajara (Fig. 1). This area is a complex and active neotectonic structure that controls and regulates the development of the rift-floor, limited by normal faults (Michaud et al., 2000; Zárate-del Valle and Simoneit, 2005). The Atemajac and Toluquilla Valleys are located in the lower Tepic–Zacoalco Rift and are bordered by hills, volcanic cones (El Cuatro, San Martín), plateaus (Tonalá) and volcanic calderas (La Primavera), among other features (Sánchez-Diaz, 2007).

Atemajac and Toluquilla valleys consist of a relatively thin cover of Quaternary lacustrine deposits overlying a thick section of Neogene volcanic rocks including silicic domes, lava and cinder cones, lithic tuffs, basalts, ignimbrites and other pyroclastic rocks, andesites and volcanic breccia, and a basement consisting of Oligocene granite (Campos-Enríquez et al., 2005; Gutiérrez-Negrín, 1988; Urrutia et al., 2000) (Fig. 2). Hydrogeologically, these valleys are underlain by two aquifers (Fig. 3). The upper aquifer consists of alluvial and lacustrine sediments, pre-caldera pyroclastic materials (Tala tuff) such as volcanic ash flows and lapilli, and rhyolitic domes. It represents an unconfined aquifer of about 450 m thickness (Sánchez-Díaz, 2007; CONAGUA, 2010) with hydraulic conductivities ranging from 1.6 x 10^{-7} to 2.0 x 10^{-4} m/s and porosities from 20 to 40%. Groundwater recharge sources of this aquifer are rainwater and ascending vertical fluids from the lower aquifer (Gutierrez-Negrin, 1991). Groundwater flows via faults and Toba tuffs in direction to the central and northern portion of the study area. The lower aquifer consists of fractured andesites and basalts, with hydraulic conductivities and porosities ranging from 10^{-8} to 10^{-4} m/s and from 5 to 50%, respectively. This semi-confined to confined aquifer has been related to geothermal fluids (Venegas et al., 1991; SIAPA, 2004). Groundwater of this aquifer flows preferentially in southeastern direction (Ramírez et al., 1982).

Pumping wells are drilled in the upper aquifer. Its water table distribution is shown in Fig. 2. In the Atemajac valley, groundwater flow direction is oriented mainly from southwest to northeast, from the topographically higher areas, towards the Santiago river, with possible recharge from normal faults west from Guadalajara city (Fig. 3, section I and II); while in Toluquilla the flow of groundwater circulates from northwest to southeast (Fig. 3, section III) (SIAPA, 2004; CONAGUA, 2009). However, anthropogenic activity has been changing the flow paths, resulting in the formation of different cones of depression. The major discharge is given by well pumping activities and springs in the escarpment of the Santiago river (SIAPA, 2004; CONAGUA, 2009 and 2010). Due to the heavy extractions from the aquifer system, water table levels are falling up to 2.2 m/year and 0.3 m/year on average in Atemajac and Toluquilla aquifers, respectively (SIAPA, 2004). The constructed well depth is up to 500 m and up to 380 m in the valley of Atemajac and Toluquilla, respectively. Depth to water table is up to 150 m in the Atemajac valley and typically less than 50 m in Toluquilla valley (SIAPA, 2004).

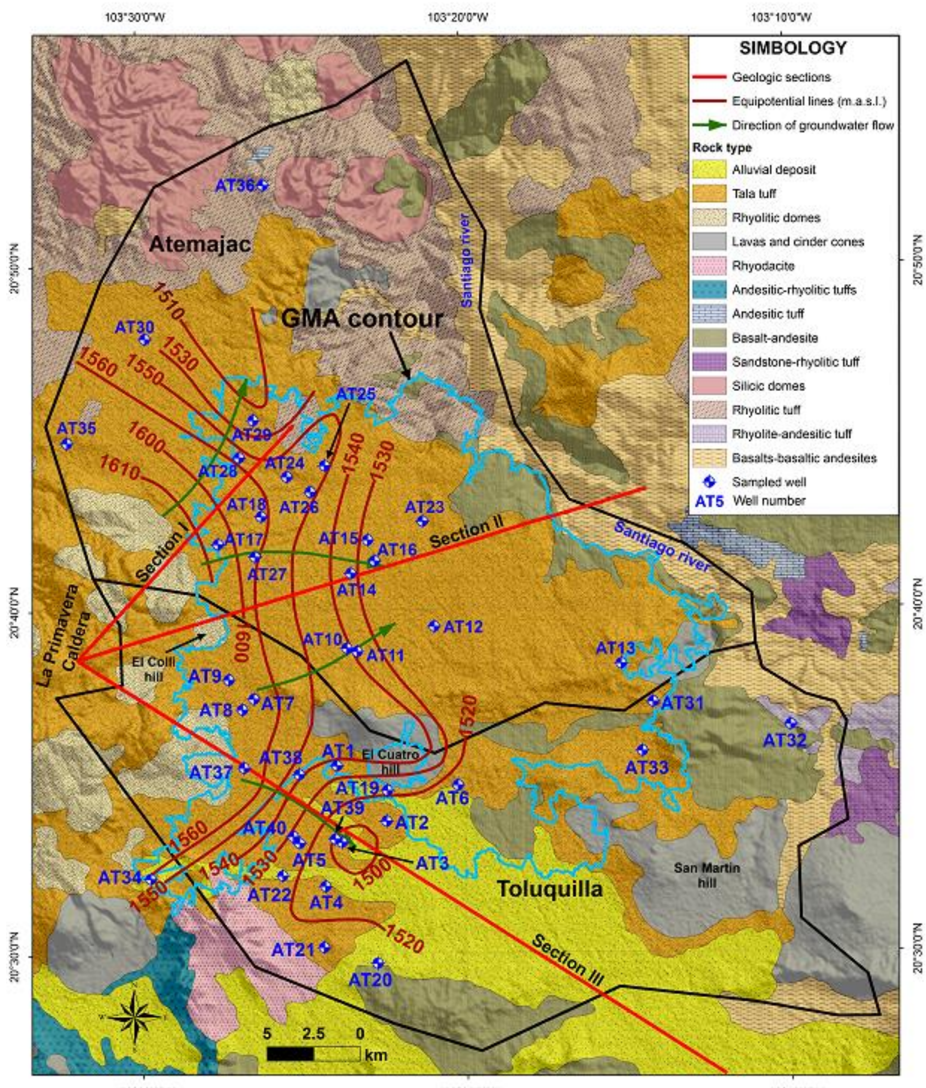

Figure 2: Surface geology, water table distribution and location of wells sampled in the study area. Note: GMA = Guadalajara metropolitan area

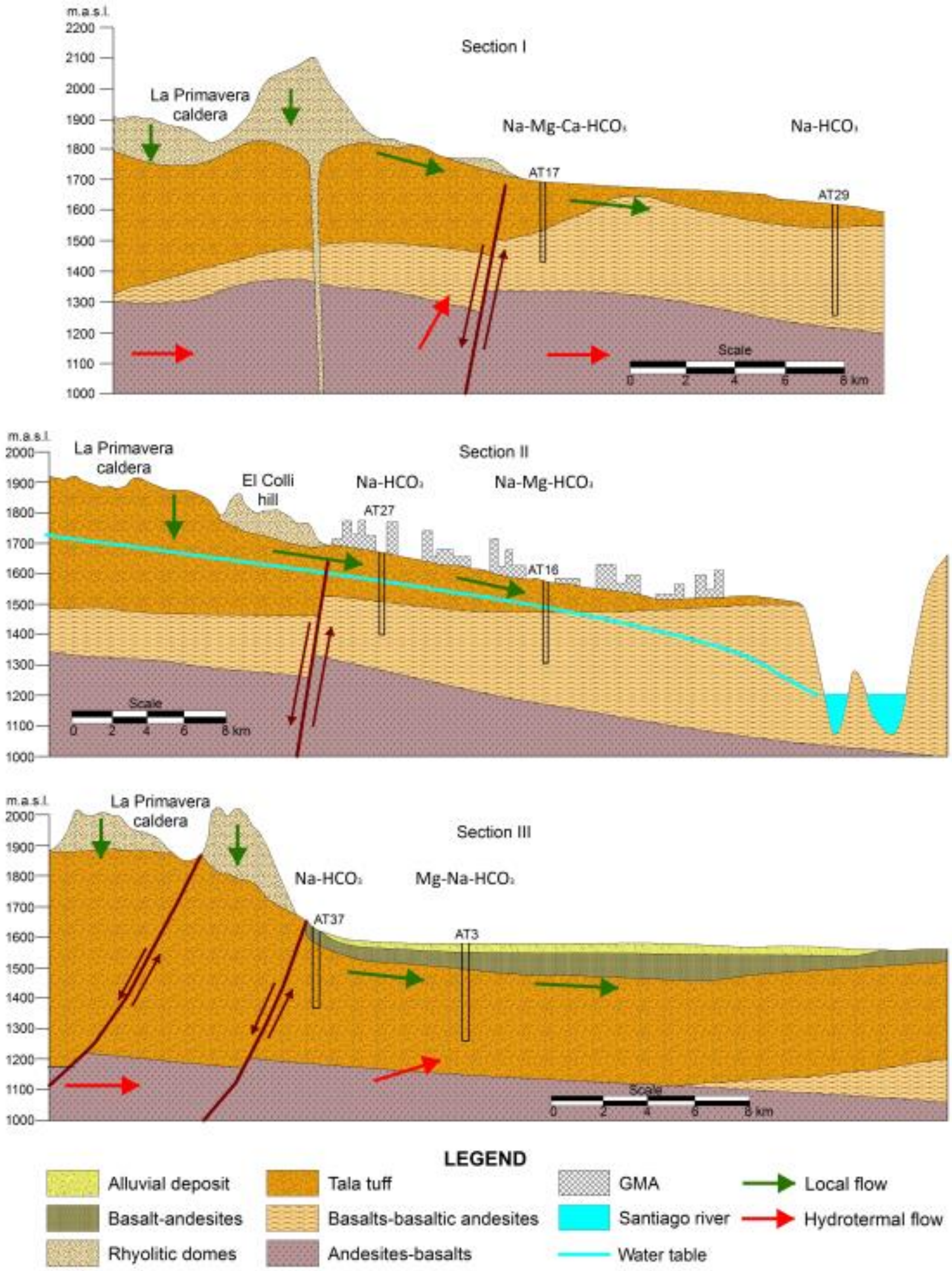

Figure 3: Cross-sections indicated in Fig. 2 and considering hydrogeological settings and water types of selected wells.

4. Section 3.2:

d) "Techniques of analysis" seems describe better the contents of this paragraph instead of "Interpretation".

A: We accept your suggestion and attend it correspondingly in the manuscript.

5. Section 4.4:

A. Spatial distribution of groundwater types should be discussed consistently with the conceptual hydrogeological model and vice versa.

A: We agree with you and modify Section 4.4 as follows:

The hydrogeological Atemajac-Toluquilla system is located in the northeastern area of the Tepic-Zacoalco Rift, a complex and active neotectonic structure.

Local groundwater recharge for Atemajac-Toluquilla Valley originates from rainfall mainly over the La Primavera caldera in the central western portion of the study unit. It flows from the upper alluvial sediments towards the valley floor and Santiago River. Recharge water is of Na-HCO_3 water type with low temperatures, salinities, Cl and Na values, elevated NO_3 concentrations, as well as relatively high tritium activities in the range of 0.5 -2.9 TU indicating little mixing of flow paths and recent recharge from pristine soils and infiltration from agricultural plots. This result confirms also a relatively fast transport through the unsaturated zone (Herrera and Custodio, 2014). As groundwater circulates in northeastern (Atemajac valley) and eastern direction (Guadalajara city) following the hydraulic gradient, its temperature and salinity increases moderately. The wells are typically drilled in Tala tuff underlain by andesites to basaltic andesite rocks. Locally groundwater evolves to a Na-SO_4 to mixed HCO_3 water type, with relatively high contents of SO_4, NO_3, Na, Cl and tritium (~2TU) indicating an important impact from anthropogenic pollution in urban Guadalajara.

Underground heat flow suggests the existence of a magma chamber below the La Primavera caldera, which provides hydrothermal fluids observed on surface expressions such as the La Soledad solfatara and the Cerritos Colorados geothermal field. Regional groundwater that is in contact with these fluids circulates through the lower Atemajac-Toluquilla aquifer specifically below Santa Anita and Toluquilla (Sánchez-Díaz, 2007). These Mg-HCO_3 to mixed HCO_3 waters are characterized by elevated temperatures, salinity, Cl, Na and HCO_3 values, low tritium values (<1.7 TU) and contain considerable concentrations of Li, Mn, B and F, indicating thermal influence, circulation through an active volcanic center and fault zones, and water-rock interactions. The corresponding wells are typically drilled in basalt-andesitic rock formations. The well depth of these wells range from 200 to 300 m and depth-to-water table is about 50 m. The low tritium concentration indicates pre-modern infiltration. Low tritium concentrations in deep wells, according to Herrera and Custodio (2014), are due to a mix of water from the upper aquifer and the vertical ascending flow from the lower aquifer. On the other hand, the tritium shows that geochemically speaking, the water predominates as an old fraction (Custodio, 1989)

The isotopic composition of groundwater confirms the interconnectivity between water from deeper and shallow rock materials. Practically all groundwater sampled contains at least a small fraction of modern water. The proportions of hydrothermal fluids in sampled well waters ranged from 13 (cold groundwater) to 87% (hydrothermal water), while the proportion of polluted water is between 0 and 63%.

6. Figures 2 and 8:

B. Fig. 2 seems to be not an ordinary hydrogeological map because it does not represent hydrostratigraphic units with a description of the related hydrogeological characteristics;

C. Fig. 2 should be associated to a hydrostratigraphic column provided with information about their hydrogeological characteristics, etc.;

D. groundwater flow paths are too approximate, not supported by explanations of a related conceptual groundwater flow model and not indicating to which aquifer they are related (e.g. surficial or deep);

E. topographic contour lines are not well visible.

A: We agree with you. Fig 2 was modified, hydrostratigaphic characteristics were described in the text (section 2.1, see above), groundwater flow paths are added to Fig. 3, the text indicates that they relate to the upper aquifer; topographic contour lines were eliminated and water table contour lines added.

7. Figures 3 and 5:

F. **results reported in these geochemical graphical analyses should be reported in Fig. 2 or in other figures showing geographical distribution of groundwater types.**

A: new Fig 3. shows water types of selected wells along cross section.