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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Groundwater origin, flow regime and geochemical evolution in arid endorheic watersheds: a case study from the Qaidam Basin, Northwest China" *by* Yong Xiao et al.

Anonymous Referee #2

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General comments

This is potentially and interesting study and it is a nice dataset. However, it needs to have much more work done on it before it is publishable in a major journal such as HESS. The paper is brief and there is a lack of justification of key points. In particular, the interpretation of the 14C and the major ions is speculative at best. There is also insufficient details on the hydrogeological framework to understand the data in context.

I hope that these comments are useful in revising the paper.

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Discussion paper

Abstract

The Abstract provides a reasonable summary of the paper, some specific comments.

1) Line 13 – be specific about which results show this.

2) The water types (lines 18-20) are just a descriptive and do not by themselves indicate much about process. “Water-rock interaction” and “evaporation-precipitation” also are general descriptions. It would be better to specify exactly what minerals are involved in these reactions.

3) The % of water from the systems (line 22) cannot be that precisely estimated.

Introduction

The introduction references a lot of literature, but needs more details. You should outline the specific issues that you are addressing in this paper more fully – it is good to mention a range of features (resources, ecology etc) but the main purpose of this paper, which is to understand the hydrogeology, needs more emphasis. You should expand this section to explain in more detail how this work specifically addresses an important hydrogeology question and how it relates to our understanding of groundwater in these types of basins in general.

HESS is an international journal and so papers need to appeal to readers working in other regions, so it is critical that you explain the general importance of the work. Perhaps refer to basins elsewhere and explain the common questions that this study will help to address.

Specific comments

Page 2 lines 13-17. This just says that it was difficult to do the research; perhaps more importantly is some indication as to why this information would be useful.

Page 2 lines 18-27. Be specific with the term “isotopes” as there is a considerable difference between the information that you get from the stable isotopes (O & H) and

radioactive isotopes such as 14C. Better to specify which ones.

You need to develop the aims better. You can do this either by framing a hypothesis or by explaining the aims more fully. At the moment, you just say that there are some techniques that we can use to help us understand groundwater systems and you are going to apply them to this basin. What specifically do you hope to achieve and how will it inform the understanding of this basin and similar ones?

Study Area

The study area section needs more detail. This is a hydrochemistry paper that as background requires an understanding of the hydrogeology. However, many details are lacking, such as:

1) You should describe what is known about the flow system, for example where are the recharge and discharge areas?

2) The maps should show recharge areas and groundwater flow paths

3) What do we know about hydraulic properties (especially K)?

Without this information it is very difficult to understand the study and the statement "Overall, groundwater in the basin originates from Golmud River seepage and bedrock lateral flow in the alluvial fan, and topography results in flow towards the low-lying depression (basin center)." is hard to assess.

Materials and Methods

For the groundwater samples, you need more details on the wells. The interpretation of data from long-screened production wells is more difficult than from monitoring bores with short screens and no pumping.

I do not see a data table in the paper (the tables are just summaries). It is critical that you provide the raw data (HESS will let you do this as a supplement). For the groundwater samples, you need to specify

a) The well depths and typical screen intervals

b) Whether these are monitoring or production wells

c) The aquifer that is sampled

The table also needs your geochemical data in it and details such as sampling date etc. The actual data is an important part of this study and must be made available with the paper.

The 14C analyses involved using a field precipitation technique. As discussed by Aggarwal et al. (2014: Groundwater, 52, 20-24) this is prone to errors by atmospheric contamination. Did you assess the possibilities that atmospheric contamination has occurred (using field blanks or repeated samples)? At the very least, you should discuss this.

Page 4, line 22. It is not clear what you mean by "The standard deviation of analytical results ranges between 0.7 pMC and 1.0 pMC" Is this from repeat analyses or is it a typical range from the lab (and why the range of values?).

As noted above, you need to include these data in a Table

Section 3.2. There are many values in here but little indication as to where they come from. Some of these details need to be in Section 2 as they are part of the background understanding. Without a clear description of the hydrogeology and flowpaths it is difficult to assess the appropriateness of the modelling (recharge is mentioned here, but it has not been explained where the recharge areas are and what any prior estimates of recharge are).

Section 4

Table 1 is only a summary table, we need the data!

This section is a reasonable description of the data. However, it is a little brief in places and as discussed below, this does not help with the interpretation. I am not sure that

defining water types is that useful as ion ratios are probably more use for understanding processes (it is a common but slightly outdated way of discussing hydrogeochemistry). While it is true that waters do "evolve" in composition from rainfall to brines (page 6, lines 13-20), that tells us little about the processes that cause them to do so.

There is some material here that is discussion and so belongs later (eg page 6, lines 9-10) and some overly speculative conclusions (eg page 6, lines 19-20) that need to be properly justified or omitted. Conversely, there is some material in section 5 (such as the description of the Na/Cl ratios) that should be here as this is where you present the data.

This section needs restructuring so that all the data that you use to make interpretations is presented and described adequately.

Section 5 Perhaps due to the tendency to explain aspects of the study briefly, and a lack of primary data, there are several conclusions in this section that are questionable (or at least need more explanation).

The interpretation of the 14C residence times (page 9) has several issues:

a) Most importantly, you seen to have samples with low 14C but measurable Tritium (Fig. 3). If so these must be mixtures between older water (low 14C, 3H free) and younger water (high 14C and high 3H) as the time required for measurable 14C to decay wipes out all the 3H. You CANNOT calculate residence times from such waters. A clear explanation of how the radioisotopes are behaving is required before you do any calculations

b) Secondly, just saying that you applied the Tamers model or an unspecified statistical is inadequate. The correction of 14C ages is commonly difficult and needs more justification (there are numerous papers that address this in many basins). Even if in the end you just use a simple correction, you need to justify that you understand what is happening in the C-system and rule out possibilities such as open-system carbonate

dissolution or methanogenesis. Also you need to outline what the % of dead carbon is and whether that is reasonable.

c) The Tamers model implicitly assumes that only carbonate dissolution occurs. However, in moderately saline groundwater, you may have carbonate precipitation. Have you assessed this?

d) Do you have 13C data? They would help in the correction process.

e) If you are going to calculate ages, you need to discuss them formally (what is the range, what are the uncertainties etc?)

The interpretation of the evaporation based on the stable isotopes (page 8, lines 15-17) seems to imply that evaporation is occurring along the flow paths. However, evaporation is something that can only occur at or near the surface and not directly from deeper groundwater. Do you mean that different degrees of evaporation occurs in different areas during recharge? If so, how does that fit with your conceptualisation of the hydrogeology?

In several places, the similarity or differences in the geochemistry are mentioned, but there are no attempts to quantify this (the reader has to basically look at the figures or tables and make their own assessment). At the very least put the ranges and differences in means in the text, but preferably try to use something like PCA or ANOVA to better justify this.

Section 5.2 on the hydrogeochemistry also has several issues.

a) The first part of the section is really just an (old) textbook introduction. Yes, these processes control the geochemistry, but the details are more subtle than this. Figure 6 is just a broad generalisation and while it is a useful conceptualisation, it does not tell us much about specific processes (which is the objective here)

b) The subsequent statements on lines 22-30 are unjustified. You need to relate this discussion back to the description of the geochemistry and explain specifically how

you came to these conclusions (ie what in the hydrogeochemistry tells us that water-rock interaction has occurred, what minerals are dissolving / precipitating etc). At the moment your interpretation just relies on where in the system the water is from (this might be correct but it does not make use of any of the geochemistry).

c) Na/Cl ratios are nor definitive in constraining halite dissolution. Rainfall has Na/Cl ratios that are close to 1 (generally 0.7-1.2) and given that ion exchange may also occur, you cannot distinguish evaporation and halite dissolution. Really you need Br and to look at Cl/Br ratios as halite dissolution produces Cl/Br ratios that are orders of magnitude higher than halite dissolution. The SI indices are not relevant.

d) The explanation of the geochemical processes on page 10 would be helped if the mineralogy of the aquifer had been properly described (which of any of these minerals exist – that is obviously important).

e) Finally, it is not clear why the authors have looked at the geochemistry in this much detail. While understanding the geochemistry is important, it should inform a broader understanding of the system, for example: does it constrain inter-aquifer mixing or where the water was recharged, is it useful for interpretation of 14C ages, is there a palaeowater signal in the major ions as well in the stable isotopes that could be useful in detecting climate influences elsewhere. As it is, this section stands alone and is actually not well integrated to the study.

Conclusions

This is a reasonable summary of the main findings of the paper. However, as with the introduction, it needs a couple of extra paragraphs to explain the relevance to researchers working elsewhere (what perhaps have you done differently / better to other studies, are there any general points in understanding basins that you can make?). This will give the paper considerably more impact.

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Discussion paper