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The Cryosphere Discussions

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4, C1379–C1384, 2010

Interactive Comment

Interactive comment on "Isotope hydrological studies on the perennial ice deposit of Saarhalle, Mammuthöhle, Dachstein Mts, Austria" *by* Z. Kern et al.

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First of all we would like to say thanks to Martin Kralik for their valuable comments and critics on the manuscript. Below we are to respond to his general and specific comments. We mark our responses by bold.

Referee's General Remarks: This is an interesting paper which tries to test the suitability of perennial ice deposits in caves with detailed isotope investigations as proxy for the age and origin of cave waters and their paleo-climatological implications. However, basic characteristics of the cave temperature and ventilation, the type and the structure of overlying rocks as well as the potential hydrology during ice formation are not discussed in detail. In addition, the meso- and micro-structure of the ice-core and the potential presence of dispersed minerals in the ice are not documented

Authors: The brief paragraph with basic information about the cave has been completed with all the demanded details and has been collected into a new section. Further information about cave temperature, ventilation regime and overburden are given. However the meso- and micro-structure of the ice was not feasible to study on this ice core. The reason is that this manual drilling device breaks/twists the ice. However we want to emphasize that any advanced electromechanical drilling equipment was not (and is still not) possible to apply in Saarhalle being ∼350m distance from the show cave part of the cave where electricity is available. In addition, some information about the dispersed insoluble impurity particles has been included into the revised version.

Referee's Specific Remarks: 1452 l. 12: which technique has been used to detect smaller amounts of minerals in the ice or in the ice-water shortly after melting the ice-core.

Authors: Insoluble impurities were described after inspection samples in binocular microscope (Zeiss Discovery V20 SteREO). Four types of insoluble impurity have been observed. To characterize their observed relative variability a primitive three grade classification has been applied. These are described in details in an inserted new subsection (3.6.) within the Material and Methods main section.

1452 l. 12: Indicate what depth range you are covering by the 8 samples and how much water was used for the tritium analysis.

Authors: The 8 measured samples distributed over the upper 1.2m and 15ml water was distilled and used for analysis. This information on depth range is inserted into the methods.

1453 l. 3: Write the full name by using the abbreviation HAS for the first time.

Authors: It is modified as suggested.

1453 l. 4: Report the estimated error of the detection limit of 8.5 TU.

Authors: According its definition no error is associated to the detection limit, but instead it corresponds to the probability level of 95 %.

1453 l. 9: Are the reported EC-values corrected to 20° or 25° C?

Authors: the reported EC values were corrected to 25 °C.

1453 l. 9: How much of the 12 ml have been used for CO2- and H2-equilibration.

Authors: 1-1 ml has been used for equilibration at each measurement.

1454 l. 9: The most recent description of the ANIP-network can be found at the Umweltbundesamt home-page (http://www.umweltbundesamt.at/en/umweltschutz/wasser/isotopen/) and the available data (up to 2009) of the surrounding stations (Bad Aussee, Feuerkogel, Salzburg and Golling) can be extracted.

Authors: The most recent updated dataset has been extracted from the recommended database and used in preparation of the revised discussion.

1454 l. 16: What is the evidence that the ice deposit melted from the top to the bottom mainly?

Authors: The surface dynamics of any ice block should be regarded as a sum of basal and surface balance. However basal melting rate is theoretically constant as it is governed by the geothermal heat. (It was found also practically constant at the very few detailed monitored ice caves like Monlési Ice Cave (Luetscher et al. 2007) and Scarisoara Ice Cave (Persoiu 2005)). So short-term changes (i.e. decadal/annual) in ice level surely mirror changes in the surface mass balance.

1455 l. 8: Using the Viennese and Feuerkogel data (1973-2009) the piston-flow model (no mixing with younger precipitation data) indicate that the present tritium values in the ice-core could be below the critical value of 8.5 TU originating from precipitation

2-28 and >48 years before collecting the samples.

Authors: Yes we agree. This part has been rewritten taking into account also the comment of Referee1.

1455 l. 20: The recharge of precipitation can be assumed to be between 1600 – 2500 m above sea-level for this part of the Dachstein massif. The altitude (427m) and the temperature conditions of the Golling station are not comparable to the Dachstein plateau. The Feuerkogel station is at the lower altitude range. In addition, we have to assume changes in the mean delta oxygen values in the range of 1-2 per-mil over the last 100 years as an increase of the oxygen value of about 0.5-1 per-mil has been observed between 1978 and 2004 in many stations. The linear regression is somewhat ambiguous as -10.9‰ would be in agreement with summer precipitation, but the low deuterium excess is not agreement with elevated values commonly found in mountain stations (see Feuerkogel, Patscherkofel and Villacher Alpe data; KAISER et al.2001; FRÖHLICH et al. 2008). In addition, one has to find good arguments to prevent winter water to infiltrate the caves. The variation of oxygen-18 data should be plotted versus depth for better interpretation.

Authors: The recommended delta vs depth plot has been included as a part of the new Fig.3. In addition the closest long-term running mountain station, Feuerkogel is used as reference for the local precipitation in the revised version. We have to remark that dD values were not presented in Humer et al. 1995 for Feuerkogel and the nearest station where both d18O and dD were available was Golling. Hence waterline was possible to determine only for Golling and that was the reason why it was used in the earlier version.

1456 l. 11-15: Describe the mechanism of evaporation under almost saturated conditions in more detail and give references to similar situations.

Authors: This vague hypothesis will be deleted from the revised version.

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Interactive Discussion

Discussion Paper

1456 l. 11-15: Well monitored springs of this Dachstein area (Brunnbach, Waldbach-Ursprung, Hirschbrunn, and Koppenbrüller-spring; 1996-2009 and SCHEIDLEDER et al. 2001) in the framework of the Austrian (WGEV)-water quality monitoring (http://www5.umweltbundesamt.at/h2ogispub/webgisKarte.do;jsessionid=E2889546E196C2D0CC4D82E83B69676F.h2o400webgis?wfjs_enabled=true&wfjs_orig_req=/webgisKarte.do?stateId=GW&mobjart=KKMST,PGMST) show a similar seasonal variation in the range of 100 – 250 μS/cm (25°C). Even lower values measured in the ice-core are in the range of precipitation indicating a minimal contact with soils or carbonate rocks. A direct condensation and freezing from water-vapours cannot be excluded. The bars with the range of cave "cave dripwater" and meltwater stream in Fig. 4 is misleading. First of all "cave dripwater" can be derived from a "meltwater streams" and secondly the EC-values in various karst areas are influenced by many factors as dissolved CO2, soil thickness, infiltration velocity, limestone/dolomite ratio, additional easily soluble sulfate minerals etc.

Authors: Yes, we agree and accept this point. The three nearest springs were selected from the dataset of Scheidleder et al. 2001. These are Koppenbrüllerquellen, Meisenbachquelle and Hirschbrunn. Their stable isotope and conductivity data were used in an improved/revised interpretation. Conductivity values of these three springs ranged from 9 μS/cm to 200 μS/cm. The minimum seems to be an outlier as the rest of the values are distributed in the 120 – 200 μS/cm range. This latter range was adopted in the new discussion as the fluctuation range of the "local karstwater".

KAISER, A.; SCHEIFINGER, H.; KRALIK, M.; PAPESCH, W.; RANK & STICHLER, W.; (2002): Links between meteorological conditions and spatial / temporal variations in long – term isotopic records from the Austrian precipitation network. Intern. Conf. "Study of Environmental Change Using Isotope Techniques", 23-27 Apr. 2001, C&SPaperSeries 13/P, 67-77, IAEA, Vienna. FRÖHLICH, K.; KRALIK, M.; PAPESCH, W.; RANK, D.; SCHEIFINGER, H. & STICHLER, W. (2008): Deuterium Excess in Precipitation of Alpine Regions – Evaluation of Sub-cloud Evaporation and Moisture Recycling. Isotopes in Environmental and Health Studies, 44, 61 – 70, Taylor & Francis. SCHEIDLEDER, A.; BOROVICZENY, F.; GRAF, W.; HOFMANN, T.; MANDL, G.; SCHUBERT, G.; STICHLER, W.; TRIMBORN, P. & KRALIK, M. (2001): Pilotprojekt "Karstwasser Dachstein“: Bd. 2 Kasrthydrologie und Kontaminationsrisiko von Quellen. Umweltbundesamt Monographie 108 / Archiv f. Lagstättenforschung 21, Geologische Bundesanst., 155 S., Wien.

Authors: Two of the recommended references were available. Both provided useful data to revise the earlier version of the interpretation and have been included into the reference list of the revised manuscript.

Interactive comment on The Cryosphere Discuss., 4, 1449, 2010.