Libor Elleder (CA): Answers to Neil Macdonald (NM)

NM The paper is worthy of publication, however as a native English speaker it requires considerable work to ensure that the paper is articulating the findings clearly and concisely.
I have attempted to help with the annotated comments; however, I am unable to work through the whole paper in detail because of time constraints, this requires extensive reworking.
1/ I would recommend reviewing the sub-heading titles and shortening them in places e.g. 5.1 is too long.

CA The text was proofreded and by a native spakerm a professional proofreader.

NM Figure 4: it would be helpful to have a full image of the stone as an insert depicting the four sections, and then present these four sections as you have them - the combined image is embedded in Table 4.

CA: This is a good idea. Unfortunately, the pictures available are very similar to the upper part of the scan in Fig., 4 however due the confusing shadows and light and bad reading of the marks are not suitable for publication.

Dear reviewer, I hope , I accepted and corrected all points you highlighted.

NM, Line 19

Bohemia and Saxony. So far, the hunger stones have been regarded rather as an illustration of dry seasons. Our aim was, among other issues, to draw attention to the much greater documentary value of hunger stones and individual dry year marks inscribed on them. Therefore, we wanted to verify their

CA: OK

The greater ~~documentary~~ value, „documentary" was deleted

Our aim was, among other issues, to draw attention to the much greater value of hunger stones and individual dry year marks inscribed on them.

NM Line 22-23

reliability and better understand the motivation of their authors. For this purpose, we used the current extreme drought period of 2014-2019 which allowed detailed documentation of hunger stone in Děčín with marks from 1536 to 2003. Thanks to the helpful position of the object near the water gauge, we could compare the measured mark heights with the corresponding water levels. Simultaneously, we

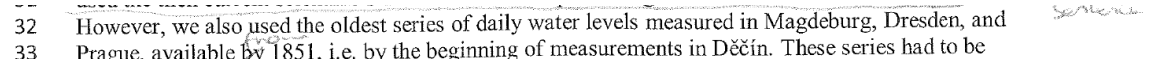
CA: Thanks to the helpful position of the stones relative to the water gauge, we could compare the measured mark heights to the corresponding water levels.

NM Line 30-31

29 Děčín is therefore a unique example of epigraphic indication of low and high water levels in the
30 enclosing profile of the upper part of the Elbe river basin. To verify the marks of low water levels we
31 used the then current scientific studies which in the past brought the identification of dry periods.

CA: To verify the low water level marks or drought marks (DM) we used the then current scientific studies focussing on dry periods.

NM Line 33-35

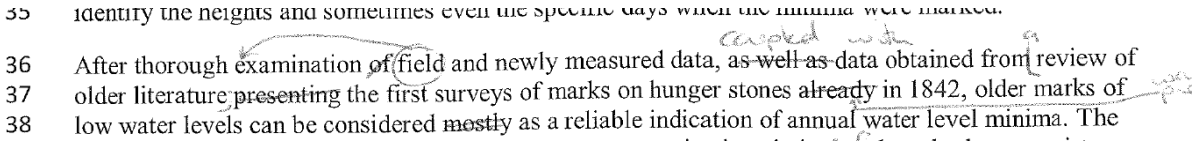


However, we also used the oldest series of daily water levels measured in Magdeburg, Dresden, and Prague, available by 1851, i.e. by the beginning of measurements in Děčín. These series had to be

CA: However, we also used the oldest series of daily water levels measured in Magdeburg, Dresden and Prague, available from 1851, i.e. the beginning of measurements in Děčín. These series had to be reconstructed or digitised from CHMI archive sources

However, we also used the oldest series of daily water levels measured in Magdeburg, Dresden, and Prague, available from 1851, i.e. by the beginning of measurements in Děčín.

NM: Line 36-37

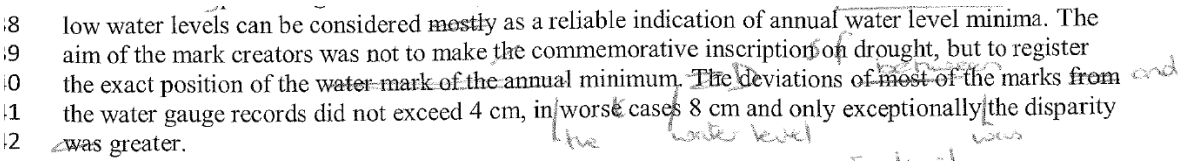


identify the heights and sometimes even the specific days when the minima were marked.

After thorough examination of field and newly measured data, as well as data obtained from review of older literature presenting the first surveys of marks on hunger stones already in 1842, older marks of low water levels can be considered mostly as a reliable indication of annual water level minima. The

CA: After a thorough field examination and newly measured data, coupled with data obtained from a review of older literature presenting the first surveys of marks on hunger stones as presented in 1842, older marks of low water levels can be considered as a reliable indication of the annual water level minima.

NM: Lines 39-40



low water levels can be considered mostly as a reliable indication of annual water level minima. The aim of the mark creators was not to make the commemorative inscription on drought, but to register the exact position of the water mark of the annual minimum. The deviations of most of the marks from the water gauge records did not exceed 4 cm, in worse cases 8 cm and only exceptionally the disparity was greater.

CA: The aim of the mark creators was not to make commemorative inscriptions of droughts, but to register the exact minimum water level. Deviations between the marks and the water gauge records did not exceed 4 cm, in the worse case the water level was 8 cm and only exceptionally was the disparity greater.

NM: Lines 43-45

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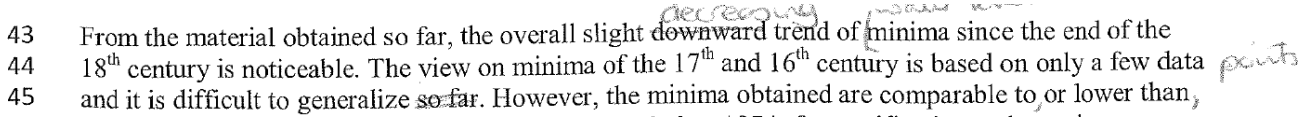

From the material obtained so far, the overall slight downward trend of minima since the end of the 18th century is noticeable. The view on minima of the 17th and 16th century is based on only a few data and it is difficult to generalize so far. However, the minima obtained are comparable to or lower than,

CA:

From the material obtained so far, an overall slightly decreasing trend of water level minima since the end of the 18th century is noticeable. The view on minima of the 17th and 16th centuries is based on only a few items of data and it is difficult to generalise.

NM Lines 46-47

45 and it is difficult to generalize so far. However, the minima obtained are comparable to or lower than,
46 the data from the critical dry periods of 1842, and 1858 to 1874. Our verification and certain
47 rehabilitation of low water level marks should be an incentive to process all available epigraphic

CA: Our verification of low water level marks should be an incentive to process all available epigraphic documents of this kind in the near future in closer cooperation with colleagues from Saxony.

NM:Lines 54-56

51 **1. Introduction**
52
53 In recent years, the phenomenon of drought has become the most prominent manifestation of climate
54 change in Central Europe. However, its objective evaluation and the evaluation of its extremity is
55 often a problem. The reason consists in difficult to grasp the phenomenon of drought or varying
56 impacts of it, respectively. Drought alongside the floods, though, rank among the most commonly
57 evaluated hydrological extremes. While the flood is caused by an unexpected and short-term excess of
58 water that causes damage, hydrological drought follows long-term deepening of water scarcity.

CA:

In recent years, the phenomenon of drought has become the most prominent manifestation of climate change in Central Europe. However, objective evaluation and assessment of its extremity is challenging, due to difficulty in describing the phenomenon of drought and the varying impacts of it. Drought, along with floods, ranks among the most commonly evaluated hydrological extremes.

NM: Lines 56-58

56 impacts of it, respectively. Drought alongside the floods, though, rank among the most commonly
57 evaluated hydrological extremes. While the flood is caused by an unexpected and short-term excess of
58 water that causes damage, hydrological drought follows long-term deepening of water scarcity.

CA: While a flood is caused by an unexpected and short-term excess of water that causes damage, hydrological drought follows a long-term deepening of water scarcity.

NM Lines 59-64

59 Our contribution is focused on hydrological drought, more precisely on minima of water stage of
60 surface water streams. The low water level and flow rate after long periods of deficit precipitation
61 represent particularly valuable information about the basin runoff. Therefore, they also report on the
62 base-flow, the groundwater accumulation, long-term depletion and hydrological drought propagation
63 (van Loon, 2015). The minimum water level or flow is, to a large extent, summary information on the
64 status of a given river basin.

CA:

Our contribution is focused on hydrological drought, more precisely on the minima of low levels. Low water level and flow rates after long periods of precipitation deficit represent particularly valuable information about catchment hydrology. Therefore, they also report on the base-flow, the groundwater accumulation, long-term depletion and hydrological drought propagation (van Loon, 2015). The minimum water level or flow is, to a large extent, summary information on the status of a given river basin.

NM: Lines 67-74

67 usually cover not more than 150 years. The longest hydrological series of measurements in Cairo 622-
68 1933, representing 1311 years of Nile observation (Shanin, 1985), was used to assess drought and its
69 interrelations with phenomena such as El Nino. In Europe, the longest series comprising
70 measurements of water levels in Magdeburg started in 1726 (see the following text), and the
71 measurements in Paris that started in 1731 (Delametherie, 1800). However, it is not possible to
72 conceal another complication, namely the later beginning of systematic hydrometric measurements
73 which are mostly available only since the end of the 19th century. This makes it difficult to estimate
74 flow rates somewhere. Therefore, stable profiles where we can assume the validity of the rating curve
75 as far back as possible are very valuable. Systematic series of water stages are therefore testimony on

CA: The longest hydrological series of measurements in Cairo, A.D. 622- A.D. 1933, representing 1,311 years of Nile observation (Shanin, 1985), was used to assess drought and its interrelations with phenomena such as El Niño. In Europe, the longest continuous series comprising measurements of water levels, in Magdeburg, started in 1726 (see the following text), and the measurements in Paris started in 1731 (Delametherie, 1800). However, it is impossible to conceal another complication, namely that systematic hydrometric measurements have, for the most part only been available since the end of the 19th century. Stable profiles where we can assume the validity of the rating curve as far back as possible are very valuable. Systematic series of water stages are, therefore testimony on runoff fluctuations, but partly also on changes in the stream cross-section and the catchment, both natural and anthropogenic.

NM Lines 75-77:

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76 runoff fluctuations, but partly also on changes in the stream cross-section both natural and
77 anthropogenic.

CA:

Systematic series of water stages are, therefore testimony on runoff fluctuations, but partly also on changes in the stream cross-section and the catchment, both natural and anthropogenic.

NM, Line 78-80:

77 anthropogenic.
78 Studies that focus on the identification of past dry periods and possibly on the wider context within
79 NAO, ENSO oscillations (e.g. Mikšovský et al., 2019) are mostly based on an analysis of precipitation
80 deficit or indicators that include temperature and hence loss by evaporation. They are necessarily

CA: Studies that focus on the identification of past dry periods and possibly on the wider context within NAO, ENSO oscillations are based mostly on an analysis of precipitation deficit or indicators that include temperature and hence loss by evaporation (e.g. Mikšovský et al., 2019).

NM, Lines 82-84

82 documentary sources. However, if we want to describe how the rainfall deficits and other weather
83 influences were reflected in the runoff from the surveyed river basin, we have the options so far rather
84 limited.

CA: However, if we want to describe how the rainfall deficits and other weather influences were reflected in the runoff from the surveyed river basin, the options we have so far are rather limited.

NM, Lines 87-88

85 Based on the available series of daily flow rates in Děčín (1851-2015), Brazdil et al. (2015) referred to
86 a period of low flows between 1858 and 1875. With the help of deficit volume analysis with fixed
87 annual (Q_{95}) and variable monthly threshold (Q_{95m}), they pointed out to drought corresponding to the
88 1904, 1911 or 1947 dry periods. The authors elaborated in detail selected dry years 1808, 1809, 1811,

CA With the help of deficit volume analysis with a fixed annual (Q_{95}) and variable monthly threshold (Q_{95m}), Brazdil et al. (2015) identified the drought events of 1868 and 1874 as comparable to the 1904, 1911 and 1947 dry periods.

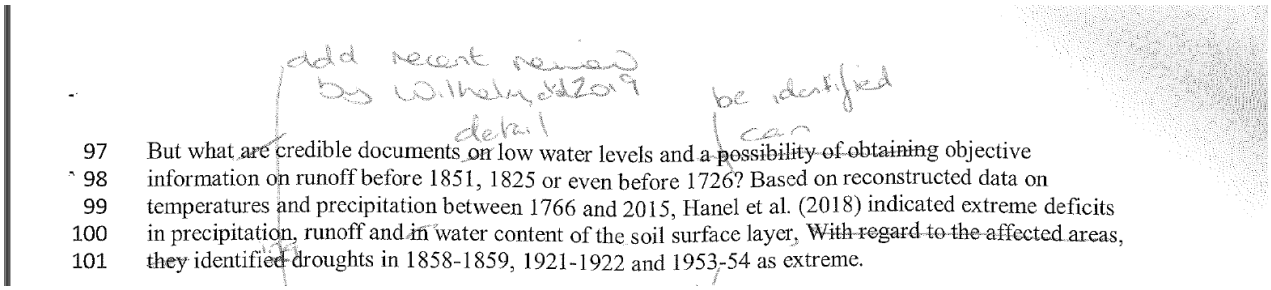
NM, Lines 90-94

88 1904, 1911 or 1947 dry periods. The authors elaborated in detail selected dry years 1808, 1809, 1811,
89 1826, 1834, 1842, 1863, 1868, 1904, 1911, 1921, 1934, 1947, 1953, 1959 and 2003, i.e. 8 cases in
90 each century representing a total of 16 cases selected on the basis of the lowest Z-index and SPI1
91 values out of 10 homogenized precipitation series (Brázdil et al., 2012). Evaluation of particular years
92 includes meteorological and synoptic conditions, drought impacts, monthly values of air temperature,
93 precipitation, SPI1, SPEI1 and Z-index. Concerning the identification of the hydrological drought in
94 the 1860s and 1870s, a similar result was reached by Elleder et al. (2019) when analysing the

CA The authors elaborated in detail the selected dry years of 1808, 1809, 1811, 1826, 1834, 1842, 1863, 1868, 1904, 1911, 1921, 1934, 1947, 1953, 1959 and 2003, i.e. 8 cases in each century representing a total of 16 cases selected on the basis of the lowest Z-index and SPI1 values out of 10 homogenised precipitation series (Brázdil et al., 2012). The evaluation of particular years includes the meteorological and synoptic conditions, drought impacts, monthly values of air temperature, precipitation, SPI1, SPEI1 and Z-index. In the identification of hydrological drought in the 1860s and 1870s, a similar result was reached by Elleder et al. (2019) when analysing the catastrophically dry year 1874 by analysing the newly reconstructed series of water levels in Prague (1825-1890).

Remark: In this study was used standardized precipitation SPI-1 index for month to evaluate yearly distribution of precipitation in selected years

NM, Lines 97-101



97 But what are credible documents on low water levels and a possibility of obtaining objective
98 information on runoff before 1851, 1825 or even before 1726? Based on reconstructed data on
99 temperatures and precipitation between 1766 and 2015, Hanel et al. (2018) indicated extreme deficits
100 in precipitation, runoff and in water content of the soil surface layer. With regard to the affected areas,
101 they identified droughts in 1858-1859, 1921-1922 and 1953-54 as extreme.

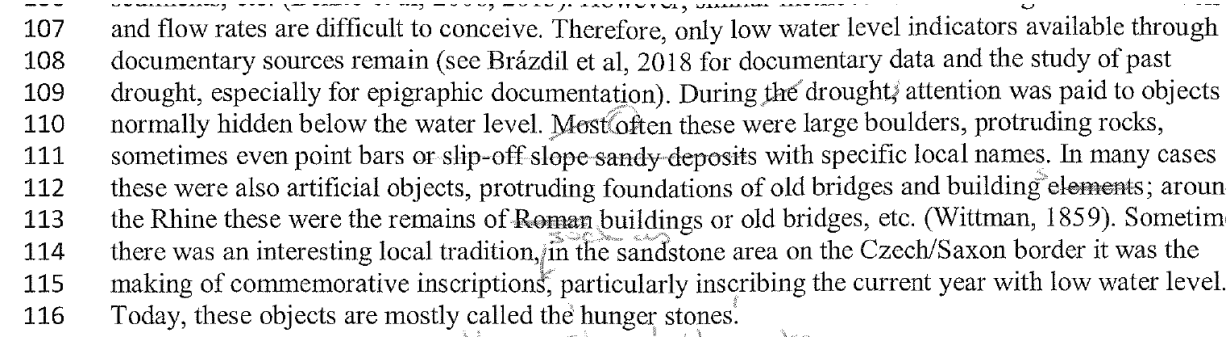
CA: I included two of citations: Wilhelm et al (2019) and Schulte et al (2019)

But what credible documents of low water levels existed before 1851 (the start of record-keeping in Děčín), 1825 (the start of record-keeping in Prague) or 1727 (the start of record-keeping in Magdeburg)?

Based on reconstructed data on temperatures and precipitation between 1766 and 2015, Hanel et al. (2018) indicated extreme deficits in precipitation, runoff and water content of the soil surface layer, identifing the droughts of 1858-1859, 1921-1922 and 1953-54 as extreme.

However, there is no doubt, similar to flood analysis, that verifying the model results according to the actual water level and flow rate increases their credibility considerably. We have a relatively large range of palaeostage indicators to describe the maximum water levels during a flood. These palaeoflood indicators comprise various types of sedimentary (e.g. slackwater flood deposits) and botanical evidence such as impact marks and damage on trees (Benito et al., 2004, 2015, Wilhelm et al., 2019, Schulte et al. 2019).

NM Lines 107-116



107 and flow rates are difficult to conceive. Therefore, only low water level indicators available through
108 documentary sources remain (see Brázdil et al, 2018 for documentary data and the study of past
109 drought, especially for epigraphic documentation). During the drought, attention was paid to objects
110 normally hidden below the water level. Most often these were large boulders, protruding rocks,
111 sometimes even point bars or slip-off slope sandy deposits with specific local names. In many cases
112 these were also artificial objects, protruding foundations of old bridges and building elements; aroun
113 the Rhine these were the remains of Roman buildings or old bridges, etc. (Wittman, 1859). Sometim
114 there was an interesting local tradition, in the sandstone area on the Czech/Saxon border it was the
115 making of commemorative inscriptions, particularly inscribing the current year with low water level.
116 Today, these objects are mostly called the hunger stones.

CA:

Therefore, low water level indicators available through documentary sources are unique data records (Brazdil et al., 2018) for recording past hydrological droughts, with the precision given by physical imprints provided by epigraphic marks.

During the drought, attention was paid to objects normally hidden below the water level. Most often these were large boulders, protruding rocks and sometimes even point bars or slip-off slope sandy deposits with specific local names. In many cases these were also artificial objects, protruding foundations of old bridges and building elements; around the Rhine these were the remains of old buildings or old bridges etc. (Wittman, 1859). Sometimes there was an interesting local tradition; in the sandstone area on the Czech/Saxon border it was the creation of commemorative inscriptions, particularly inscribing the current year with the low water level. Today, these objects are mostly called hunger stones.

Lines 117-119

NM:

117 This article focuses on them wishing to clarify their purpose, origin and meaning. Traditionally, water
118 management experts and historians and perhaps ethnographers in Bohemia considered inscriptions and
119 year indication on hunger stones to be an interesting phenomenon symbolizing drought. At the same

CA: This article focuses on these hunger stones; it seeks to clarify their purpose, origin and meaning. Traditionally, water management experts and historians and perhaps ethnographers in Bohemia considered inscriptions and the year as indicated on hunger stones to be an interesting phenomenon symbolising drought.

124 We have therefore focused on the Děčín city located in the lower section of the Czech part of the Elbe
125 river basin. The most well-known hunger stone is located here ~~and all important height~~ surveying of
126 all the ~~signs were carried~~ out in the summer of 2015. In 2018 the whole stone was scanned. This
127 article discusses to what extent the inscription years have the character of a historical minimum water
128 level.

CA: We have therefore focussed on the city of Děčín, located in the lower section of the Czech part of the Elbe river basin. The best-known hunger stone is located here and all important height surveying of all the epigraphic marks was undertaken in the summer of 2015. In 2018 the whole stone was scanned. This article discusses to what extent the inscription years have the character of historical minimum water levels.

NM

129 Objectives

130 1. To document and explain in more detail the phenomenon of hunger stones.
131 2. When are the year-marks only commemorative for that dry year and when do they represent
132 the exact records of the annual minimum water levels?
133 3. Are there ~~apparent~~ relations in the heights of minima on different stones?
134 4. What is the relation to the systematic series of measurements?
135 5. Do the elevations suggest any trend in water levels?

Objectives

1. To document and explain the phenomenon of hunger stones in more detail.
2. Are the year marks only commemorative for that dry year and when do they represent exact records of annual minimum water levels?
3. Are there consistent relations in the heights of stage minima among different stones?
4. What is the relation to the systematic series of measurements?
5. Do the elevations suggest any trend in water levels?

NM, lines 138-142

2. Described region Czech-Saxon Switzerland and Děčín town

The Elbe river valley between Litoměřice and Pirna was made famous by a number of prints and paintings by 19th century romantic painters such as Adrian Zinggs (1734 – 1816) and Caspar David Friedrich (1774 – 1840). A. Zinngs born as a Swiss, who lived in Dresden, probably coined the name of the region Saxon Switzerland, and later extended to the Czech — Saxon Switzerland (Frölich – Schauseil, A., 2018). The Elbe, which leaves the territory of the Czech Republic in the deep rocky

CA: Following the reviewer (R1) advice I changed the title

The Elbe river valley between Litoměřice and Pirna was made famous by a number of prints and paintings by 19th century Romantic painters such as Adrian Zinggs (1734 – 1816) and Caspar David Friedrich (1774 – 1840). Zinngs was Swiss, but lived in Dresden; he probably coined the name of the Saxon Switzerland region, which later extended to Czech — Saxon Switzerland (Frölich – Schauseil, A., 2018).

NM, lines 147-152

the sandstone plateau (350-450 m a. s. l.). Protruding volcanic formations reach a height of 500-800 m a. s. l. The Děčín and Hřensko cross-sections represent the closing profiles of the Czech part of the Elbe. In addition to wood, the local sandstone was a traditional building and sculptural material here and throughout the North Bohemian region. However, it was also used for rich epigraphic production on the spot — on rocks and boulders (Jenč, P., Peša, V., Barus, M. 2008). It is quite logical that water levels were recorded at river where possible, both minima and maxima.

CA: In addition to wood, local sandstone was a traditional building and sculptural material here and throughout the North Bohemian region. However, it was also used for rich epigraphic production on the spot — on rocks and boulders (Jenč, Peša, Barus, 2008). It is quite logical that water levels were recorded adjacent to the river where possible, both minima and maxima.

At the centre of our study is the Děčín city (Fig. 1) known among other things for its unique series of flood marks (Brázdil et al., 2005, Elleder, 2016a) and by just explored hunger stone. The earlier documentation (see the following text) which comes from commission inspections of the Elbe riverbed revealed previously unknown facts. In 1842, there were still in total three hunger stones in th Děčín city with engraved years, two on the left [HS1, HS3] and one on the right bank upstream the ferry [HS2] (Protokoll, 1842). The preserved stone [HS3] which is located in the lower part of the deeper riverbed is in the centre of our attention.

CA: At the centre of our study is the city of Děčín (Fig. 1), known among other things for its unique series of flood marks (Brázdil et al., 2005, Elleder, 2016a) and hunger stone. The earlier documentation, which comes from commission inspections of the Elbe riverbed revealed previously unknown facts. In 1842, there were still a total of three hunger stones in the city of Děčín with engraved years, two on the left bank [HS1, HS3] and one on the right bank upstream of the ferry crossing [HS2] (Protokoll, 1842). The preserved stone [HS3] which is located in the lower part of the deeper riverbed is the centre of our attention.

NM: lines 165-168

There were at least two places in Děčín that were problematic from the navigation point of view. Th first hunger stone [HS1] was located near the first water shallows area. It is related to the confluence of the Elbe River with the Ploučnice River from the right, the Jílovský stream from the left and sediment deposits. This place with a ford at the confluence and below the protruding sandstone ridg

CA. It is related to the confluence of the Elbe River with the Ploučnice River entering from the right, the Jílovský potok stream from the left and the sediment deposits.

NM: lines 168-174

168 sediment deposits. This place with a ford at the confluence and below the protruding sandstone ridge
169 was probably advantageous long ago as a settlement. At the end of the 13th century a royal town was
170 founded here, Fig.1, (Velimský, 1991). Possibly in connection with the period of ~~a significant~~
171 occurrence ~~of floods~~ between 1342 and 1374 (Elleder, 2015) it was abandoned and transferred ~~as a~~
172 serf city to the other side of the rock ridge where a castle stood and nowadays the manor house is
173 situated. On the rock under the castle there are flood marks from 1432 carved into the rock block.

CA: This place was probably advantageous long ago as a settlement with a ford at the river confluence and below the protruding sandstone ridge. At the end of the 13th century a royal town was founded here (Fig.1, Velimský, 1991). Possibly in connection with the period of a significant occurrence of floods between 1342 and 1374 (Elleder, 2015), it was abandoned and transferred to the other side of the rock ridge, where a castle stood and the manor house is situated nowadays. There were at least two places in Děčín that were problematic from a navigational point of view. The first hunger stone [HS1] was located near the first water shallows area.