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1 Early Cretaceous topographic evolution associated with the collapse of the Mongol-

2 Okhotsk orogen in Western Transbaikalia: an integrated analysis

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11 Abstract

12 The Early Cretaceous topographic evolution of Transbaikalia was largely governed by the
13 tectonic evolution of the Mongol-Okhotsk orogenic belt. The collapse of the Mongol-Okhotsk
14 orogen triggered the formation of metamorphic core complexes and associated extensional basins,
15 widespread throughout Transbaikalia, North Mongolia, and North China. Numerous lithofacies
16 and biostratigraphic studies have been carried out from the sedimentary deposits of the
17 Transbaikalia basins. However, the absence of absolute ages for the sedimentary series, as well as
18 sediment source-to-sink analysis do not allow to accurately characterize the regional topographic
19 evolution. We focused our study on the Gusinoozersk Basin of Western Transbaikalia, where
20 extensive sedimentary sections of Lower Cretaceous deposits have been preserved. We provide
21 new U/Pb (LA-ICP-MS) data on detrital zircons from sedimentary series and ⁴⁰Ar/³⁹Ar data on
22 intruding rocks. We review the paleontological data to clarify the age of the paleogeographic
23 events associated with the collapse of the Mongol-Okhotsk orogen, as well as to correct the age of
24 faunal complexes in Western Transbaikalia. Our geochronological results show that the formation
25 of the Cretaceous basins of Transbaikalia began around ~~130~~136–136–130 Ma, accompanying the
26 main episode of extension associated with the exhumation of the metamorphic core complexes.
27 The lowest coarse-clastic formation characterizes the rapid subsidence and the predominance of

1
2 28 proximal sediment sources. Distal provinces also made a contribution to sedimentation indicating
3
4 29 the rise of a positive topography characterizing the exhumation of the metamorphic core
5
6 30 complexes. Overlying fine-grained formations indicate a significant smoothing of the topography,
7
8 31 suggesting that from middle Aptian, Western Transbaikalia developed in a relatively calm tectonic
9
10 32 regime. We also show that the basins of Transbaikalia were formed both in conjunction with the
11
12 33 exhumation of metamorphic cores complexes and reactivated structural sutures. Revised data on
13
14 34 dinosaur fauna and palynology, together with the dating of host deposits, provide insights on the
15
16 35 Early Cretaceous paleoenvironmental evolution.
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23 37 **Keywords:** U–Pb detrital zircons dating; sediment source-to-sink analysis; topographic evolution;
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25 38 Western Transbaikalia.
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30 40 1. Introduction

31
32 41 The Mesozoic topographic and environmental evolution of Transbaikalia was largely driven by
33
34 42 the tectonic evolution of the Mongol-Okhotsk orogenic belt (see fig. 1A for location). The belt
35
36 43 was formed as a result of the closure of the Mongol-Okhotsk Ocean which extended between the
37
38 44 Siberian and Mongolian-North China continents from the Late Paleozoic to the Mesozoic
39
40 45 (Zonenshain et al., 1990; Sengör and Natal'in, 1996; Yin and Nie, 1996; Zorin, 1999). Most
41
42 46 geodynamic models indicate a scissor-like closure of the ocean from West to East from the
43
44 47 Permian to the Middle Jurassic (Zonenshain et al. 1990; Nie et al., 1990; Nie, 1991; Yin and Nie,
45
46 48 1993; 1996; Zorin et al., 1998; Davis et al., 1998; Gordienko, Kuzmin, 1999; Zorin, 1999; Darby
47
48 49 et al., 2001; Parfenov et al., 2003; Donskaya et al., 2013; Demonterova et al., 2017; Sorokin et al.,
49
50 50 2020; [Wang et al., 2022](#) and others). Recent detrital zircon U-Pb data from marine and continental
51
52 51 deposits along the Mongol-Okhotsk suture showed that the last stage of ~~the~~ oceanic closure was
53
54 52 segmental. Some terranes in the central part of the ocean accreted to the Siberian continent 5–10
55
56 53 Ma later than in the western and eastern parts (Guo et al., 2017; Arzhannikova et al., 2022).

1
2 54 Although this geodynamic event has been widely studied, the topographic evolution of the
3
4 55 Mongol-Okhotsk belt is still poorly understood. Widespread magmatism and thrusting related to
5
6 56 subduction and collision suggested that the Mongol–Okhotsk belt formed as a plateau-like uplift
7
8
9 57 ([Zorin, 1999](#)). [Paleomagnetic data obtained from the Mesozoic deposits of Southeastern Siberia](#)
10
11 58 [and Northern Mongolia indicate left-lateral strike-slip motion along the Mongol-Okhotsk suture](#)
12
13 59 [zone during and after the collision, caused by the clockwise rotation of the Siberian continent](#)
14
15 60 [\(Parfenov et al., 2001; Metelkin et al., 2004, 2010\)](#). [Yang et al. \(2015\) proposed that this major](#)
16
17 61 [left-lateral strike-slip motion triggered the gravitational collapse of the thickened upper crust,](#)
18
19 62 [leading to the development of rift basins.](#) Detrital zircon dating and sedimentology study in the
20
21 63 Tugnu Basin, one of the oldest Mesozoic basins of Transbaikalia (see fig. 1B for location),
22
23 64 revealed rapid geodynamic changes from ~~the Mongol–Okhotsk~~ collision to widespread rifting at
24
25 65 about 168 Ma ([Arzhannikova et al., 2020](#)). The paleogeographic reconstruction showed that the
26
27 66 region was subjected to several stages of compression and extension associated with an oblique
28
29 67 collision that took place at different times in the Middle and Upper Jurassic in different regions of
30
31 68 Transbaikalia ([Yang et al., 2016](#); [Arzhannikova et al., 2020; 2022](#)). The main stage of collapse of
32
33 69 the Mongol-Okhotsk orogen is associated with the exhumation of metamorphic core complexes
34
35 70 and the formation of rift basins, widely distributed over Transbaikalia, North Mongolia (Fig. 1B),
36
37 71 and within the North China Craton. This widespread, highly distributed extension phase occurred
38
39 72 between 138 Ma and 110 Ma, with a peak at 130–125 Ma ([Zheng et al., 1991](#); [Sklyarov et al.,](#)
40
41 73 [1997](#); [Zorin et al., 1997](#); [Zorin, 1999](#); [Donskaya et al., 2008](#); [Daoudene et al., 2013, 2017](#); [Wang](#)
42
43 74 [et al., 2011, 2012](#); [Ivanov et al., 2015](#); [Zhang et al., 2019](#)). Numerous paleontological,
44
45 75 paleobotanical, lithofacies and biostratigraphic studies have been carried out from the sedimentary
46
47 76 deposits of the Transbaikalia rift basins (e.g. [Martinson, 1961](#); [Kolesnikov, 1961; 1964](#); [Otchirov,](#)
48
49 77 [1964](#); [Serdobolskaya and Kozubova, 1976](#); [Skoblo et al., 2001](#); [Jolivet et al., 2017](#); [Arzhannikova](#)
50
51 78 [et al., 2018](#)). However, the absence of absolute ages for the sedimentary series ~~does~~ did not allow
52
53 79 to accurately characterize the regional topographic and environmental evolution.
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1
2 80 The Cretaceous basins of Transbaikalia are nonetheless key objects to study the destruction
3
4 81 of the Mongol-Okhotsk orogen and the corresponding paleoenvironmental evolution. These basins
5
6 82 represent a unique record of the Cretaceous fauna, flora, climate and topography of this huge
7
8 83 region. One of the key depressions, where extensive sedimentary sections of Cretaceous deposits
9
10 84 have been preserved, is the Gusinozersk Basin of Western Transbaikalia (see fig. 1B for location).
11
12 85 Sediments of this depression are well characterized by fossil fauna. Bonebeds containing the
13
14 86 remains of dinosaurs and other vertebrates were found in the sediments of the basal Murtoi
15
16 87 Formation. Based on the correlation of vertebrate faunas, ~~an assumption was made about~~ the age
17
18 88 of the sediments was estimated ranging from Late Beremian to Middle Aptian (Dmitriev, 1960;
19
20 89 Nesson and Starkov, 1992; Averianov et al, 2003), thus from ~127 to 120 Ma (here and further the
21
22 90 stratigraphic age is established according to www.stratigraphy.org assessed on 30th May 2022).
23
24 91 However, later studies of the fauna suggested that deposits in the Gusinozersk Basin could begin
25
26 92 to accumulate earlier, starting from the Late Berriasian – Valanginian (Skoblo et al., 2001) (~140
27
28 93 Ma) or Late Valanginian – Barremian (Averianov et al., 2022) (~133–125 Ma). Constraining the
29
30 94 time span in the geological record of well-preserved sediments is key to determine the
31
32 95 paleoenvironment of the region, as well as the age and correlation of non-marine vertebrates of the
33
34 96 Early Cretaceous in Transbaikalia, Mongolia, and China.
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40
41 97 The objective of this study was to bracket the age of the sedimentary series of the
42
43 98 Gusinozersk Basin based on U/Pb (LA-ICP-MS) dating of detrital zircons and ⁴⁰Ar/³⁹Ar dating
44
45 99 of an intruding dike. Carrying out absolute dating made it possible to clarify the age of the
46
47 100 paleogeographic events associated with the collapse of the Mongol-Okhotsk orogen, as well as to
48
49 101 correct the age of faunal complexes in Western Transbaikalia. This last point represents a leap
50
51 102 forwards to biostratigraphic correlations in various regions of Central Asia.
52
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54
55 103 A recent revision of the dinosaur fauna (Averianov et al., 2022) has made it possible to
56
57 104 take a fresh look at the faunal list of the complex of fossil vertebrates in the Gusinozersk Basin.
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1
2 | 105 ~~This, which~~, together with new data on age and paleogeography in this study, provides a more
3
4 | 106 complete picture of the Early Cretaceous paleoenvironments of Western Transbaikalia.
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8 | 108 **2. Geological setting**

9
10 | 109 The Gusinozersk Basin is a Cretaceous NE-SW oriented depression bounded to the NW
11
12 | 110 and SE by the Khambin and Monostoy ridges, respectively (Fig. 2). The Gusinozersk Basin was
13
14 | 111 first described as a typical graben (Luchitsky, 1975). According to Leonov (1983), two
15
16 | 112 synsedimentary tectonic structures, the Khambin and Monostoy faults, were involved in the
17
18 | 113 formation of the basin, and the onset of sedimentation was associated with the activation of the
19
20 | 114 Khambin Fault (see fig. 2 for location). Later, Bulnaev (2006) established this depression as
21
22 | 115 monoclinical, formed due to unilateral synsedimentary subsidence along the Monostoy Fault, which
23
24 | 116 runs along the eastern flank of the basin (see fig. 2 for location). Indeed, the thickness of sediments
25
26 | 117 in the depression is not constant, increasing from the western edge to the East. This indicates that
27
28 | 118 the role of the Monostoy Fault in the development of the basin was predominant (Bulnaev, 2006).
29
30 | 119 Below we present a description of the igneous complexes within the Khambin and Monostoy
31
32 | 120 ridges, as potential sediment sources, as well as a description of the sedimentary deposits of the
33
34 | 121 Gusinozersk Basin.
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36

37 | 122 **2.1. Igneous complexes of the Khambin and Monostoy ridges**

38
39 | 123 The Khambin Ridge, framing the Gusinozersk Basin ~~from to~~ the west, is composed of
40
41 | 124 two igneous complexes. The “Ichetui” bimodal volcanics are identified in the southern part of the
42
43 | 125 ridge (see fig. 2). They are also distributed within several grabens of Western Transbaikalia and
44
45 | 126 composed of trachybasalts, trachyandesites, trachydacites and trachyrhyodacites. The “Ichetui”
46
47 | 127 volcanic rocks have been dated by different geochronological methods from ~~145-168~~ to ~~168-145~~
48
49 | 128 Ma in different places of Western Transbaikalia (Gordienko et al., 1997; Ivanov et al., 1995;
50
51 | 129 Vorontsov et al., 1999; Andryushchenko et al., 2010; Arzhannikova et al., 2018). Specifically, for
52
53 | 130 the Khambin Ridge, two dates were obtained with ages of ~~~156-159~~ and ~~~159-156~~ Ma
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1
2 131 (Andryushchenko et al., 2010). The northern part of the Khambin Ridge is characterized by the
3
4 132 Sogotinsk igneous complex (see fig. 2). Three phases of intrusion are distinguished within the
5
6 133 complex: monzonites and quartz monzonites; syenites, quartz syenites and granosyenites; and
7
8 134 moderately alkaline granites and leucogranites. Geochronological dating of the Sogotinsk complex
9
10
11 135 by the K-Ar method provided an age range of ~~220~~271–~~271~~220 Ma for the granitoids, while the
12
13 136 Rb-Sr method gave an age range of ~~267~~287–~~287~~267 Ma (Platov et al., 2013).

14
15
16 137 The Monostoy Ridge is mainly composed of Paleozoic meta-sedimentary series, locally
17
18 138 intruded by the Triassic granitoids of the Malo-Kunaley complex and some Early Jurassic bimodal
19
20 139 association (Fig. 2). The Malo-Kunaley complex is represented by peralkaline granites,
21
22 140 granosyenites and alkaline syenites. A Late Triassic age of ~~2120~~–~~2120~~ Ma was determined for
23
24 141 the Malo-Kunaley granites ~~by from whole rock Rb-Sr and zircon U-Pb methods analysis, including~~
25
26 142 ~~for the area within the northeastern part of the Monostoy Ridge~~ (Yarmolyuk et al., 2000;
27
28
29 143 Litvinovsky et al., 2001; Reichow et al., 2010). The Early Jurassic bimodal association is
30
31 144 widespread in Western Transbaikalia. Within the Monostoy Ridge it is composed of a thick (over
32
33 145 2000 m) bimodal volcanic sequence (trachybasalts, trachyandesite-basalts, alkaline trachydacites)
34
35 146 with an age, determined by ~~whole rock Rb-Sr method analysis~~, of ~194 Ma (Yarmolyuk et al.,
36
37 147 2000).

41 148 2.2. Sedimentary deposits of the Gusinozersk Basin

42
43 149 The age of the sedimentary deposits is debated. The main studies were carried out in the
44
45 150 1950-1960s. Various complexes of freshwater mollusks characteristic of the Middle, Upper
46
47 151 Jurassic - Lower Cretaceous were found in different parts of the sedimentary section of the basin
48
49 152 (e.g. Martinson, 1955). According to Otchirov (1964), sedimentation began in the Gusinozersk
50
51 153 Basin from the Early Jurassic and continued up to the upper Lower Cretaceous. Kolesnikov (1961;
52
53 154 1964), based on lithological, paleontological and geological data, attributed the entire section of
54
55 155 the Mesozoic continental deposits to the Middle Jurassic - Lower Cretaceous. Based on geological
56
57 156 mapping, Komarov (1962) divided the stratigraphic section, from base to top, into the Sanga,

1
2 157 Selenga, Bain-Zurkhen and Kholboldzhin Fms. All formations were described as conformable and
3
4 158 span from the Upper Jurassic to the Lower Cretaceous (Fig. 3).
5

6 159 Subsequently, a rich collection of fossil mollusks, ostracods and plants, as well as
7
8 160 fragmentary remains of bones and teeth of dinosaurs was collected (Scoblo, 1967). This new
9
10 161 collection, as well as geological drilling data for coal exploration, raised disagreements on the
11
12 162 Mesozoic stratigraphy of the Gusinozersk Basin, leading to different interpretations of the
13
14 163 complex geological structures of this region. The scheme proposed by Scoblo (1967) differs
15
16 164 significantly from those of Martinson (1961), Kolesnikov (1961; 1964) or Otchirov (1964). In
17
18 165 particular, it suggests a complete absence of Middle and Upper Jurassic sediments in the
19
20 166 Gusinozersk Basin. Later, numerous fossil findings made it possible to expand the lists of ancient
21
22 167 fauna and flora and significantly correct the stratigraphy and distribution of fossil organisms
23
24 168 (Scoblo et al., 2001). In our work, we adhere to the stratigraphic scheme published in (Scoblo et
25
26 169 al., 2001), which is best characterized by fossil fauna. The Gusinozersk series are subdivided into
27
28 170 four formations (bottom-up) (Fig. 3):
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34 171 1. The Murtoi Fm. (K_{1mr}) (analogous to the lower sub-formation of the Sanga Fm.
35
36 172 according to Komarov (1962), (Fig. 3)), is 300-450 m thick and occurs along the western side of
37
38 173 the Gusinozersk Basin, at the foot of the Khambin Ridge. The Murtoi Fm. rests on the underlying
39
40 174 Middle and Upper Jurassic volcanic rocks through an erosional unconformity. It is composed of
41
42 175 interbedded conglomerates, gravelstones, sandstones and silicic volcanic rocks. Up section, the
43
44 176 conglomerates become finer, and the number and thickness of the sandstone interlayers increase.
45
46 177 The sorting and rounding of pebbles increase up section, which is interpreted as a decrease in
47
48 178 fluvial-environment deposits and a correlative increase in lacustrine deposits (Skoblo et al., 2001).
49
50 179 In the Mogoito locality (see fig. 2) the Murtoi Fm. contains various fossil bivalves, gastropods,
51
52 180 scattered fragmental remains of vertebrates such as palaeonisciform, acipenceriform and
53
54 181 teleostean actinopterygians, macrobaenid turtles, lizards, various ornithischian and saurischian
55
56 182 dinosaurs, pterosaurs, birds, and eutherian mammals (Skoblo et al., 2001; Averianov and
57
58
59
60

183 Skutschas, 2001; 2009; Averianov et al, 2003; Skutschas, 2008). New data on fauna and
184 palynology from the Mogoito locality make it possible to estimate the age of the formation as Late
185 Valanginian – Barremian (~133–125 Ma), although some of the data are quite contradictory and
186 require further clarification (Averianov et al., 2022).

187 2. The Ubukun Fm. (K_1 ub) (analogous to the upper sub-formation of the Sanga Fm.
188 according to Komarov (1962), (Fig. 3)) is 300-450 m thick and characterized by deep-lake
189 sediment facies. Mudstones are widespread in the lower part of the formation, interbedded with
190 siltstones and fine-grained sandstones higher-up in the section. Sandstones with small coal lenses
191 dominate tThe upper part of the section ~~is dominated by sandstones with small coal lenses~~. The
192 fossil fauna (mostly ostracods) is exclusively limnophilic, characteristic of a lake at least 50 m
193 deep (Skoblo et al., 2001). Sandy facies with coal lenses in the upper part of the formation indicate
194 shallowing of the lake and development of swamps. The biostratigraphic age of the Ubukun Fm.
195 is determined as Hauterivian (132.6–129.4 Ma) (Skoblo et al., 2001).

196 3. The Selenga Fm. (K_1 sl) forms the lower part of the coal-bearing strata of the
197 Gusinozersk series, and shows the greatest regional distribution. It is characterized by
198 transgression-regression cycles and divided into two sub-formations. The Lower Selenga sub-
199 formation (K_1 sl₁) corresponds to the Selenga Fm., and the Upper Selenga sub-formation (K_1 sl₂)
200 corresponds to the Bain-Zurkhen Fm. according to Komarov (1962), (Fig. 3)). The Lower Selenga
201 Sfm., with a total thickness of up to 600 m is represented by interbedded gravelstones, sandstones,
202 siltstones, mudstones, and coal. The grain size is decreasing up section. The sub-formation is
203 characterized by three ostracod horizons. The Upper Selenga Sfm., up to 500 m thick, lacks
204 gravelstones and is dominated by finer-grained sediments. The number and thickness of coal seams
205 in the Upper Selenga Sfm. is greater than in the Lower Selenga Sfm. Different parts of the section
206 display carbonaceous sandy shale layers (“paper” oil shale) with fish, pelecypod and ostracod
207 horizons. The sub-formation is also characterized by various bivalves and gastropods. The

1
2 208 biostratigraphic age of the entire Selenga Fm. is determined as Hauterivian-Barremian (~130 Ma)
3
4 209 (Skoblo et al., 2001).

5
6 210 4. The Kholboldzhin Fm. (K_1 hl) forms the upper part of the Mesozoic deposits in the
7
8 211 Gusinozersk Basin (Fig. 3). It has a thickness of up to 1200 m and conformably overlies the
9
10 212 Selenga Fm. The deposits are represented by polymictic arkose sandstones, siltstones and coal.
11
12 213 The coal occurrence in this formation is the highest in the Gusinozersk Basin, displaying more
13
14 214 than 16 coal seams with a thickness of 2-4 to 53 m. The deposits contain ostracods and small
15
16 215 bivalves. The biostratigraphic age of the Kholboldzhin Fm. is determined as Barremian-Aptian
17
18 216 (~129.4–113 Ma) (Skoblo et al., 2001).

19
20
21
22 217 The Monostoy foothill series form a separate stratigraphic unit along the foot of the
23
24 218 Monostoy Ridge and is represented by colluvions, conglomerates, breccias, gravelstones with
25
26 219 sandstone interbeds. Drilling data show that sediments of this series are laterally correlated to fine-
27
28 220 grained sediments in the basin, starting from the Lower Selenga Sfm. (Bulnaev, 2006; Skoblo et
29
30 221 al., 2001) (Fig.3). This indicates that, starting from the time of the accumulation of the Lower
31
32 222 Selenga Sfm., the Monostoy Fault played the main role in the subsidence of the basin.

33
34 223 The correlation of sections in several areas of the Gusinozersk Basin is based on the
35
36 224 complexes of fauna (especially ostracods and mollusks) and takes into account all the geological
37
38 225 and structural data. Though numerous intra-formation erosion surfaces are exposed, the overall
39
40 226 stratigraphy seems conformable, without major erosion lags. Biostratigraphically, this is
41
42 227 confirmed by the succession of faunal complexes and the stability of the plant association
43
44 228 throughout the Lower Cretaceous. The composition of the flora from individual formations and
45
46 229 sub-formations indicates that they evolved under similar paleoenvironmental conditions (Skoblo,
47
48 230 1967; Skoblo et al., 2001). At the same time, the variations in sediment facies assemblages and
49
50 231 depositional environments indicate different dynamics of basin subsidence.

51
52 232 The discussion above clearly shows that the age and stratigraphy of the deposits of the
53
54 233 Gusinozersk Basin have been debated for many decades. So far, no geochronological data have

234 been published on the Late Mesozoic sedimentary deposits of the basin, nor data on the evolution
235 of sediment sources. Such data are nonetheless necessary to fully constrain the onset of formation
236 of the Cretaceous basins in Transbaikalia and assess the morphostructural and paleoenvironmental
237 evolution associated with the collapse of the Mongol-Okhotsk orogen.

238

239 **3. Detrital zircon U-Pb (LA-ICP-MS) and igneous rocks $^{40}\text{Ar}/^{39}\text{Ar}$ dating**

240 **3.1. Sampling sites**

241 In this study, we selected samples from three key formations of the Gusinozersk Basin
242 and performed U-Pb (LA-ICP-MS) analysis of detrital zircons to clarify the depositional age and
243 determine the evolution of the source-to-sink pattern. The samples were taken from the basal
244 Murtoi Fm., the Lower Selenga Sfm. and the Kholboldzhin Fm, covering the entire section of the
245 Cretaceous deposits (Figs. 2, 3).

246 The Murtoi Fm. was sampled from an outcrop located near the Murtoi Valley
247 ($N51^{\circ}09.745'$; $E106^{\circ}13.630'$) (Fig. 4, sample Gus-17-1, see Fig. 2 for location). The deposits are
248 poorly sorted conglomerates composed of largely self-supported, moderately to well-rounded
249 pebbles and cobbles up to 20 cm in size with a limited sandy matrix. Pebbles and cobbles consist
250 mainly of intermediate and felsic volcanic rocks with mafic inclusions. The deposits are interpreted
251 as proluvial-alluvial facies from braided rivers. Sample Gus-17-1, collected for U-Pb (LA-ICP-
252 MS) detrital zircon dating was taken from the sandy matrix (Fig. 4C).

253 Within the studied outcrop, the conglomerates are intruded by the Murtoi dike belonging
254 to the Khurai-Baiba dike complex (Komarov, 1962) (Fig. 4A, B). The apparent width of the dike
255 is 9 m. The dike has a lamprophyric composition with inclusions of granitoid xenoliths (Khubanov
256 et al., 2017). There are at least three magmatic intrusion phases, similar in composition but
257 different in degree of crystallization (Andryushchenko et al., 2010). The dike was previously dated
258 by Rb-Sr and K-Ar methods, which yielded ages of 117 ± 6 Ma and 122 Ma (without stated
259 uncertainty), respectively (Litvinovsky et al., 1989). To clarify the age of the intrusion within the

1
2 260 studied outcrop and to establish the upper limit of the age of the sampled sedimentary unit, a
3
4 261 sample Mur-17-1 was taken from the dike for $^{40}\text{Ar}/^{39}\text{Ar}$ analysis.
5

6 262 The Lower Selenga Sfm. is represented by a 90-meter thick section in the undercut of a
7
8 263 road, NW of the basin (N51°16.491'; E106°22.275') (Fig. 5A, see position of sample Gus-14-6 on
9
10 264 fig. 2 for location) (Jolivet et al., 2017). The deposits are tilted westward. The lower (eastern) part
11
12 265 of the section is represented by medium- and fine-grained light grey sandstones alternating with
13
14 266 siltstones and rare thin coal interlayers. In the upper part of the section, the coal layers become
15
16 267 thicker (up to 1 m) and are interbedded with siltstones and fine-grained sandstones. According to
17
18 268 Martinson (1961) and Jolivet et al. (2017) such deposits characterize a subsiding, wet, densely-
19
20 269 vegetated alluvial plain environment. The change from coarse-grained to fine-grained deposits
21
22 270 with an increase in the proportion of coals indicates a retrogradation trend and a transition to a
23
24 271 lacustrine depositional environment. The fine-grained deposits and the occurrence of coal
25
26 272 interlayers suggest a low-relief topography in the area of the basin and a relatively low input of
27
28 273 clastic sediments. A sample for U-Pb (LA-ICP-MS) dating of detrital zircons (Gus-14-6) was
29
30 274 collected from a medium-grained sandstone at 61 m from the base of the logged section (Fig. 5A).
31
32
33
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36 275 The Kholboldzhin Fm. is represented by a 70-meter thick section within the Gusinozersk
37
38 276 coal deposit on the eastern shore of Lake Gusinoe (N51°09.284'; E106°25.795') (see position of
39
40 277 sample Gus-14-1 on fig. 2 for location) (Jolivet et al., 2017). The section displays interbedded grey
41
42 278 siltstones with plant remains, rare interlayers of fine- to medium-grained sandstone, and coal
43
44 279 seams up to 3 m thick (Fig. 5B, C). This facies assemblage is interpreted as lacustrine to marsh
45
46 280 depositional environments. The upper ~20 m of the section are represented mainly by fine- to
47
48 281 medium-grained sandstones with a calcareous and clay cement, interpreted as meandering river
49
50 282 facies (Jolivet et al., 2017). A sample for detrital zircon dating (Gus-14-1) was collected from one
51
52 283 of the fine-to-medium-grained sandstone interbeds in the lower part of the section (23 m from
53
54 284 bottom) (Fig. 5B).
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58

59 285 3.2. Analytical methods and results

60

1
2 286 Sample preparation for detrital zircons analysis was carried out at the Centre for
3
4 287 Geodynamics and Geochronology of the Institute of the Earth's Crust SB RAS. U-Pb (LA-ICP-
5
6 288 MS) analysis was made at the Analytical center of mineralogical, geochemical and isotope studies
7
8
9 289 at the Geological Institute, SB RAS. The sample preparation and analytical procedures are the
10
11 290 same as described in Arzhannikova et al. (2020). The isotopic ratios measurement technique is
12
13 291 described in detail in Khubanov et al. (2016) and Buyantuev et al. (2017). For this study, more
14
15 292 than 100 zircon grains were selected from each sample, with no differentiation of size (the size of
16
17 293 the analyzed grains varied from 60 μm to 180 μm) or morphology. U-Pb analysis was performed
18
19 294 using an ICP-MS Element XR (ThermoFisher Scientific) coupled to an UP-213 laser (New Wave).
20
21 295 Zircons 91500 (1065 Ma) (Wiedenbeck et al., 1995), Plešovice (337 Ma) (Slama et al., 2008), and
22
23 296 GJ-1 (608.5 Ma) (Jackson et al., 2004) were used as external standards. The relative errors in the
24
25 297 measurement for isotope ratios in the reference standards varied within ranges of 1%–2.3% for
26
27 298 $^{208}\text{Pb}/^{232}\text{Th}$, 2.1%–2.6% for $^{207}\text{Pb}/^{206}\text{Pb}$, 1.1%–2.6% for $^{206}\text{Pb}/^{238}\text{U}$ and 2%–2.5% for $^{207}\text{Pb}/^{235}\text{U}$.
28
29 299 Analytical results were processed using the GLITTER (Griffin et al., 2008) software. Only data
30
31 300 with a concordance >90% were taken into account in the interpretation. The abundance histograms
32
33 301 and probability density curves for each sample were plotted for $^{206}\text{Pb}/^{238}\text{U}$ ages with 2σ analytical
34
35 302 uncertainty using the Dezirteer software (Powerman et al., 2021). Most U-Pb ages cluster below
36
37 303 400 Ma with few outliers showing older ages (Supplementary Data, Tables S1-S3). Therefore, we
38
39 304 used only grains younger than 400 Ma to plot the diagrams (Fig. 6).
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45 305 $^{40}\text{Ar}/^{39}\text{Ar}$ dating was carried out at the Centre for Geodynamics and Geochronology of the
46
47 306 Institute of the Earth's Crust SB RAS using an ARGUS VI mass spectrometer coupled to a double-
48
49 307 vacuum resistance oven. The age was calculated relative to the BERN4M standard with an age of
50
51 308 18.885 ± 0.097 Ma, which makes it possible to directly compare the $^{40}\text{Ar}/^{39}\text{Ar}$ and U-Pb ages
52
53 309 (Ivanov et al., 2017).
54
55

56
57 310 Ninety-one concordant U-Pb zircon ages were obtained from the basal Murtoi Fm.
58
59 311 ([sample Gus-17-1](#)). They are statistically distributed into the following populations: 150-165, 170-

185, 215-245, 250-270 and 280–300 Ma. The youngest zircon has an age of 136.1 ± 43.9 Ma (Fig. 6A; Supplementary Data, Tables S1). In the Lower Selenga Sfm. (sample Gus-14-6), 76 concordant U-Pb zircon ages were obtained. The main age population ranges 175–210 Ma, and is complemented by a minor group with ages of 225–245 Ma and few, scattered older ages. The youngest zircon present in the sample has an age of 1165.9 ± 21.7 Ma (Fig. 6B; Supplementary Data, Tables S2). In the Kholboldzhin Fm. (sample Gus-14-1), 103 concordant U-Pb zircon ages were obtained. Zircon ages are distributed into one major population at 160–230 Ma with a main peak at 191 Ma. A few older outliers are also present as in the Lower Selenga sample. The youngest zircon in the sample is 159.860 ± 21.75 Ma (Fig. 6C; Supplementary Data, Tables S3).

The $^{40}\text{Ar}/^{39}\text{Ar}$ plateau age of lamprophyre sample Mur-17-1 lamprophyres collected from the Murtoi dike is 130.0 ± 10.7 Ma (Fig. 7A). The same plateau steps form an inverse isochron with age of 130.2 ± 1.4 Ma and initial $^{40}\text{Ar}/^{36}\text{Ar}=285 \pm 63$. Because the initial argon isotope composition is equal to the atmospheric value (~ 300), the calculation of the plateau age, which assumes the atmospheric initial value, is justified. Further, we use the plateau age because it has lower analytical uncertainty.

327

328 4. Discussion

329 4.1. Age and evolution of provenance of the Gusinozersk Basin deposits

330 In sample Gus-17-1 from the Murtoi Fm. the age population of 150–~~160~~165 Ma forms a
331 significant age peak (see Fig. 6A). This age range corresponds to that of the “Ichetui” bimodal
332 volcanics identified in the southern part of the Khambin Ridge (see Fig. 2). The main age
333 population of 215–270 Ma corresponds in age to the Sogotinsk igneous complex identified in the
334 ~~southern-northern~~ part of the Khambin Ridge (see Fig. 2). The small age population of 280–300
335 Ma zircons in this sample can ~~also~~ be attributed to the ~~Angara-Vitim batholith~~Sogotinsk complex.
336 Finally, tracing the provenance of the 170–185 Ma zircons is a challenge. Almost no igneous
337 rocks of this age have been found in Western Transbaikalia or Northern Mongolia. The only dating

1
2 338 of syenites in this range (178 ± 3 Ma) is situated in the Burgutuy massif of the Buteel metamorphic
3
4 339 core complex (Mazukabzov et al., 2006) (see Fig. 1B for location).

5
6 340 In sample Gus-14-6 from the Lower Selenga Sfm., most zircons ages range 175–210 Ma
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8 341 (see fig. 6B), which can be attributed to the syenites of the Burgutuy massif, as well as to the Early
9
10 342 Jurassic bimodal association, identified within the Monostoy Ridge. A small population with an
11
12 343 age of 225–245 Ma matches the age of the Sogotinsk igneous complex.

13
14
15 344 In sample Gus-14-1 from the Kholboldzin Fm., almost all zircons ages are 160–230 Ma,
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17 345 with the maximum number occurring between 160 and 200 Ma (see ~~fig~~Fig. 6C), as in the Selenga
18
19 346 Sfm. ~~sample~~.

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21
22 347 As ~~can be seen from~~evidenced by the histogram of the age distribution of detrital zircons
23
24 348 from the Murtoi Fm. (Fig. 6A), the contribution of proximal sources located in the Khambin Ridge
25
26 349 in the total amount of zircons is major. The mostly coarse-grained deposits suggest that most of
27
28 350 the clastic material was transported by braided rivers draining the Khambin Ridge. The minor
29
30 351 zircon population of 170–185 Ma indicates a small contribution to the sedimentation from more
31
32 352 distant provinces located to the south in the area of the Burgutuy massif of the Buteel metamorphic
33
34 353 core complex (see fig. 1B for location). In the overlying Selenga and Kholboldzhin Fms., zircons
35
36 354 brought from the Khambin Ridge are practically absent, except for a small population with an age
37
38 355 of 225–245 Ma. The main source of sediments in these formations appears to be the Monostoy
39
40 356 Ridge and the Buteel metamorphic core complex. Syn-tectonic biotite $^{40}\text{Ar}/^{39}\text{Ar}$ age and U-Pb age
41
42 357 of metamorphic zircon from the footwall of the Buteel metamorphic core complex indicate that its
43
44 358 exhumation occurred between 138 Ma and 122 Ma (Mazukabzov et al., 2011), possibly exposing
45
46 359 the 178 ± 3 Ma Burgutuy massif to erosion and providing a new sediment source for the
47
48 360 Gusinozersk Basin. A fine-grained lithology of the Selenga and Kholboldzhin Fms. sediments
49
50 361 reflects a smoothing of the topography in the region, suggesting a low-intensity tectonic regime.
51
52 362 The slow subsidence of the basin during the accumulation of the Selenga and Kholboldzhin Fms.
53
54 363 was largely compensated by sedimentation mainly occurring in lacustrine-swamp depositional

1
2 364 environments with an occasional supply of coarser alluvial material associated with erosion of the
3
4 365 sides of the basin. All formations contain a few zircons with ages of 290–280–330 Ma that match
5
6 366 the age of the Angara-Vitim batholith (Litvinovsky et al., 2011) located to the north of the
7
8 367 Gusinozersk Basin. Judging by the significant occurrence of Late Carboniferous–Early Permian
9
10 368 detrital U–Pb zircon ages in the Lower–Middle Jurassic deposits of the Verkhoysk margin and
11
12 369 the Irkutsk Basin (see fig. 1B for location), the Angara–Vitim batholith region represented an
13
14 370 uplifted area up to the beginning of the Middle Jurassic (Prokopyev et al., 2008; Demonterova et
15
16 371 al., 2017; Mikheeva, 2017). Until that time, the rivers draining the southern part of the
17
18 372 Angara-Vitim batholith transported the clastic material southward to the Mongol-Okhotsk
19
20 373 continental margin. The closure of the Mongol-Okhotsk Ocean in the region of Western
21
22 374 Transbaikalia at the Early and Middle Jurassic boundary led to a reorganization of the drainage
23
24 375 network and a change in the direction of transport of sedimentary material to the north
25
26 376 (Arzhannikova et al., 2020). The occurrence of zircon ages corresponding to sources both north
27
28 377 and south of Western Transbaikalia in one sample indicates recycling of sediments from previous
29
30 378 deposits (Yang et al., 2013), as it has been observed for the Middle Jurassic deposits of the
31
32 379 neighboring Tugui Basin (Arzhannikova et al., 2020) (see fig. 1B for location). The pre-existing
33
34 380 cover sequence at the Mongol-Okhotsk continental margin, containing zircons derived from the
35
36 381 Angara-Vitim batholith, was probably still largely preserved by the Early Cretaceous and
37
38 382 participated to the clastic material source. Although the contribution of recycled zircons to the
39
40 383 deposits of the Gusinozersk Basin is not significant: in the Murtoi Fm., zircons with the age of
41
42 384 the Angara-Vitim batholith do not exceed 7%, and only single grains of this age are found in the
43
44 385 overlying formations.

45
46 386 Single zircon grains with ages ranging from 330 to 400 Ma are found in samples from the
47
48 387 Lower Selenga Sfm. and Kholboldzhin Fm. There are no zircons of this age in the sample from
49
50 388 the Murtoi Fm. In the adjacent areas, volcanic rocks with such ages are not known (Wang et al.,
51
52 389 2022); therefore, the question of the provenance of these zircons remains open.

1
2 390 The youngest generations of zircons in the samples were found in the Murtoi Fm. and
3
4 391 Lower Selenga Sfm. These are composed of a very few single grains with ages ranging from ~116
5
6 392 to 145 Ma (Fig. 6 A,_B). These ages correspond to the ages of single paleovolcanoes of
7
8 393 trachybasaltic and trachyandesite composition in the Khambin Ridge (~~124~~127–127–124 Ma)
9
10 394 (Andryushchenko et al., 2010), large volcanoes of alkaline rhyolites (~140 Ma), including those
11
12 395 within the Monostoy Ridge (Yarmolyuk et al., 2000), as well as two stages of magmatic activity
13
14 396 that occurred in Western Transbaikalia at ~~135~~143–143–135 Ma and ~~111~~131–131–111 Ma
15
16 397 (Vorontsov et al., 2016). In their study, Vorontsov et al. (2016) pointed out that after 135 Ma, the
17
18 398 emitted volume of volcanic rocks sharply decreased and their composition changed from bimodal
19
20 399 associations to basaltoid ones. The predominance of mafic rocks among the Early Cretaceous
21
22 400 volcanics (up to 90%) ([Donskaya et al., 2013](#); [Sheldrick et al., 2020](#)) possibly explains the small
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24 401 amount of zircons of this age in the samples.

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27
28
29 402 Thus, our geochronological studies made it possible to clarify the onset time of the
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31 403 formation of the Gusinozersk Basin. While it was previously considered as Middle Jurassic to
32
33 404 Early Cretaceous (Komarov, 1962; Martinson, 1961; Kolesnikov, 1964; Otchirov, 1964; Skoblo
34
35 405 et al., 2001 and others), our detrital zircon U-Pb age data from the basal Murtoi Fm. indicate that
36
37 406 the basin began to subside not earlier than ~136 million years ago (according to the age of the
38
39 407 youngest zircon in the sample). However, this age of ~136 Ma relies on a single grain and is
40
41 408 therefore statistically very weak. A more representative number of young zircons (3 grains) have
42
43 409 an age of ~~150–~~153 Ma (Supplementary Data, Tables S1). However, the age of ~136 Ma is in
44
45 410 better agreement with the biostratigraphic data. Based on freshwater mollusks, Kolesnikov (1980)
46
47 411 estimated the age of the Murtoi Fm as Berriasian – Valanginian (~~~145–~~132.9 Ma). Based on the
48
49 412 age of the ostracods, Scoblo et al. (2001) dated the Murtoi Fm. as Berriasian–Hauterivian (~~~145–~~
50
51 413 129.4 Ma). The spore-pollen assemblages associated with the overlying Selenga and
52
53 414 Kholboldzhin Fms. are characterized by Late Jurassic species, while the flora macro-remains in
54
55 415 the same deposits are Early Cretaceous ([see for example the Old Zagustay samples in](#) Jolivet et
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57
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59
60

1
2 416 al., 2017). [Jolivet et al. \(2017\)](#) also reported the occurrence of few Cretaceous spores and pollens
3
4 417 [from the Selenga SFfm., finally suggesting that the Selenga, Bainzorkhen and Kholboldshin Fms](#)
5
6 418 [beare of late Late Jurassic – Early Cretaceous age.](#) Averianov et al. (2022) identified spore-pollen
7
8 419 spectra from the Murtoi Fm., which correspond to those that were widespread across Siberia in the
9
10 420 Lower Cretaceous. For some species (*Foraminisporis asymmetricus* and *Rouuseisporites*
11
12 421 *reticulatus*), the lower stratigraphic limit corresponds to the middle of the lower Valanginian
13
14 422 (Averianov et al., 2022), which is in good agreement with the lower age limit of the formation at
15
16 423 ~136 Ma obtained in our work from the dating of the youngest zircon. This result suggests that the
17
18 424 Jurassic spore-pollen spectra found in the Selenga and Kholboldzhin Fms. (Jolivet et al., 2017)
19
20 425 were indeed recycled from the Jurassic sediments widespread in the region in the Lower
21
22 426 Cretaceous. This would explain the discrepancy between those Jurassic spore-pollen spectra and
23
24 427 the Lower Cretaceous age of the flora macro-remains found in the same formations. [Indeed, while](#)
25
26 428 [spores and pollens are small and resistant enough to be recycled from older sediment deposits](#)
27
28 429 [\(Stanley, 1966\), macro-remains, and especially soft parts such as leafs are impossible to recycled.](#)
29
30
31
32
33
34 430 Since the $^{40}\text{Ar}/^{39}\text{Ar}$ dating of the Khurai-Baiba dike complex, intruding the deposits of the Murtoi
35
36 431 Fm., showed an upper age limit of 130.0 ± 10.7 Ma for the basal formation, we suggest that the
37
38 432 formation of the Gusinozersk Basin started at ~~130~~136–136–130 Ma. These data are consistent
39
40 433 with the biostratigraphic age of the Murtoi Fm.; ~~H~~however, our new geochronological data
41
42 434 narrows the age interval for the beginning of sedimentation in the Gusinozersk Basin.

435 4.2. Taphonomy of the Mogoito locality series and paleoenvironmental application

436 Based on the fossils found at the Mogoito locality, we can model the paleoenvironment at
437 the time of the onset of sedimentation in the Gusinozersk Basin during deposition of the Murtoi
438 Fm. It yielded the largest number of vertebrate remains from the Gusinozersk Basin. The Mogoito
439 locality consists of a series of natural outcrops in shallow ravines and scours on the western bank
440 of Lake Gusinoe exposing sediments from the Murtoi Fm. The locality represents an important
441 source of information about the Early Cretaceous vertebrate fauna of Central Asia. The lower

1
2 442 alluvial-proluvial part of the Murtoi section in Mogoito locality is made of large and medium
3
4 443 pebble conglomerates of varying rounding, gravelstone and sandstone containing rare fragmentary
5
6 444 dinosaur fossils and remains of petrified wood. The upper alluvial part of the section is composed
7
8
9 445 of alluvial cross-bedded fine-to-coarse grain sandstone alternating with a thinner layer of shale and
10
11 446 siltstone with remains of bivalve mollusks and vertebrates. The remains of fossil bones are
12
13 447 randomly scattered in the sediments. There are no articulated skeletal elements here, and most of
14
15
16 448 the bones are highly fragmented. Some bones were carried by water currents and rounded.

17
18 449 ~~The main part~~A major amount of the fossils belongs to the sauropods *Tengrisaurus starkovi*
19
20 450 (Averianov and Skutschas, 2017; Averianov et al., 2021) belonging to the titanosaurs group.
21
22 451 Remains of another sauropod (Sauropoda indet.) are also present but yet under study (Averianov
23
24 452 et al., 2022). Three theropod groups have been identified from the Mogoito locality based on the
25
26
27 453 isolated bones and teeth: Ornithomimosauria, Therizinosauroida, and Dromaeosauridae
28
29 454 (Averianov et al., 2003; Averianov and Skutschas, 2009; Averianov et al., 2022). All available
30
31 455 remains previously identified as Ornithopoda indet. as well as a *Psittacosaurus* sp. (Averianov and
32
33 456 Skutschas, 2009) from Mogoito locality can be attributed to a representative of the basal
34
35
36 457 ornithischian clade Jeholosauridae indet. (Averianov et al., 2022). Remains of other diapsid
37
38 458 reptiles such as lizards, pterosaurs, turtles *Kirgizemys dmitrievi* and choristoderes
39
40
41 459 *Khurendukhosaurus* sp. (Skutschas and Vitenko, 2017) are also found. The fossil crocodyliforms,
42
43 460 another reptile group found in more southern Late Mesozoic vertebrate faunas in Mongolia, have
44
45
46 461 not been recorded so far from there. This is most likely due to the cool climate, which is not
47
48 462 suitable for crocodyliforms. ~~Although~~ ~~although~~ it is impossible to exclude the possibility that they
49
50 463 simply did not get into the paleontological record. Fish remains *Stichopterus* sp., Paleonisciformes
51
52 464 indet., cf. *Irenichthys* sp. (Averianov and Skutschas, 2009) are found in alluvial deposits. The
53
54 465 discovery of the eutherian mammal *Murtoilestes abramovi* (Averianov and Skutschas, 2001) in
55
56
57 466 one of the Mogoito gullies is noteworthy.
58
59
60

1
2 467 The Mogoito locality is largely similar to the Khuren Dukh locality of Mongolia, sharing the
3
4 468 macrobaenid turtle *Kirgizemys* and the long-necked choristodere *Khurendukhosaurus* (Averianov
5
6 469 and Skutschas, 2000). However, abundant remains of *Psittacosaurus* at the Khuren Dukh locality
7
8 470 (Kalandadze and Kurzanov, 1974) are not known in the Mogoito locality. Apparently, this
9
10 471 indicates an older age of the sediments in Mogoito, because when present, *Psittacosaurus* is the
11
12 472 most abundant dinosaur taxon in an assemblage (Averianov et al., 2022).

13
14
15
16 473 ~~We cannot use d~~Dinosaurs cannot be used as good indicators of climate because some of
17
18 474 them thrived and even bred in the cool temperate climate above the Arctic Circle, such as in
19
20 475 Kakanaut locality (Chukotka, Russia). A CLAMP analysis of the Maastrichtian Kakanaut coastal
21
22 476 paleoflora, using the Physg3brcAZ and the WorldClim2 calibration data sets, yielded a mean
23
24 477 annual temperature of ~12 °C, the warmest month having a mean temperature of ~21 °C, and the
25
26 478 coldest month a mean temperature of ~5 °C (Zolina et al., 2020). However, the absence of
27
28 479 crocodyliforms and the presence of turtles and choristoderes in the Mogoito locality suggest a
29
30 480 temperate climate, with an annual mean temperature well above freezing level but below 14°C
31
32 481 (Markwick, 1998; Mannion et al., 2015; Amiot, 2011). The sedimentation age of the Murtoi Fm.
33
34 482 (136–130 Ma, this study) coincides with the global cooling Weissert Event, which took place at
35
36 483 ~133 Ma (Cavalheiro et al., 2021) during the earliest Cretaceous (Berriasian to Barremian) and
37
38 484 can be characterized as something “in-between” a hothouse and an icehouse (Fig. 8). The average
39
40 485 global temperature was about 17°C (Scotese et al., 2021).

41
42
43
44 486 All palynological samples from the Mogoito locality revealed only rare palynomorphs
45
46 487 including spores and pollen of terrestrial plants and freshwater microphytoplankton. The low
47
48 488 counts in palynomorphs could be probably attributed to a taphonomic bias related to the coarse-
49
50 489 grained character of the deposits less favorable to the accumulation of light-weighted organic
51
52 490 material. Terrestrial palynomorphs are represented by spores of cyatheaceous/dipteridaceous,
53
54 491 osmundaceous and schizaeaceous ferns, liverworts and lycopods, ginkgoalean pollen grains and
55
56 492 saccate pollen of conifers. Stratigraphically important taxa include *Cicatricosisporites* sp.,

1
2 493 *Foraminisporis asymmetricus* and *Rouseisporites reticulatus*, which were widespread across
3
4 494 Siberia in the Lower Cretaceous (Averianov et al., 2022).

5
6 495 Taking into account the data on ostracods and malacofauna, it can be assumed that in the
7
8 496 Murtoi time there were no large deep lakes in the Gusinoozersk Basin. Water bodies rather
9
10 497 consisted in a series of small open lakes and oxbow lakes. The climate was cooler than in
11
12 498 subsequent ages although absolute temperature ranges are difficult to estimate.

13
14
15 499 The overlying Ubukun Fm. is represented by lacustrine sediments. All fossil fauna found
16
17 500 here is limnophilic. The morphological features of ostracods in the lower part of the formation
18
19 501 indicate a depth of the paleolake of 50-100 m. The main representatives of ostracods here are
20
21 502 *Mongolianella subexsortis*, *M. rocodi*, *M. substriata*, *Limnocypridea grammi* (Skoblo et al. 2001).
22
23 503 In the upper part of the formation, the faunal complex changes. Forms characteristic of small
24
25 504 marshy lakes appear. The complex of bivalves given by (Kolesnikov, 1977) contains forms
26
27 505 characteristic of the entire Gusinoozersk Series. Vertebrate remains have not been found here, with
28
29 506 the exception of one aquatic macrobaenid turtle *Kirgizemys* (similar to those found in the Murtoi
30
31 507 Fm.), which, most likely, comes from the Ubukun Fm. (Danilov et al., 2006).

32
33
34 508 The Selenga and Kholboldzhin Fms. are represented by alluvial and lacustrine-alluvial
35
36 509 deposits. The lakes were periodically swamped, and the lacustrine-swampy sediments were later
37
38 510 repeatedly eroded by the river. In the Selenga Fm. several marker horizons contain (from bottom
39
40 511 to top) *Limnocypridea defense*, *Darwinula murtoensis*, *Cypridea selenginensis*, which were living
41
42 512 in large open lakes (Skoblo et al., 2001). Marking horizons containing *Cypridea zagustaica* and
43
44 513 Ferganoconchidae correspond to the facies of shallow stagnant bodies (Skoblo et al. 2001).
45
46 514 According to (Vakhrameev, 1964, 1982), plant remains, such as *Cyparissidium gracile*,
47
48 515 *Pterophyllum sensovianum*, *Coniopteris (Birisia) onychioides*, *Sphenopteris (Ruffordia)*
49
50 516 *goeppertii*, *Onychiopsis elongate*, *Scleropteris dahurica*, belong to typical Early Cretaceous forms.

51
52
53 517 A large number of fossil remains of flora and fauna thus make it possible to reconstruct the
54
55 518 paleoenvironmental evolution of the basin. The onset of formation of the Gusinoozersk ~~basin~~ Basin

1
2 519 coincided with the global cooling Weissert Event. During that period the temperate climate
3
4 520 prevailing in Transbaikalia was favorable to the existence and reproduction of dinosaur, turtles
5
6 521 and choristoderes, but not suitable for crocodiles. Following the small-scale open-water lakes and
7
8 522 marshes of the Murtoi Fm., deep lakes (or a single, large lake) formed during the deposition time
9
10 523 of the Ubukun Fm. This is supported both by the sediment facies and the rich ostracod fauna. Later,
11
12 524 in the early Selenga Sub-fm. time, the lakes periodically decreased in size, and in the late Selenga
13
14 525 and Kholboldzhin times, there were again a series of small swampy lakes.

18 526 **4.3. Tectonic evolution of the Gusinoozersk Basin**

20 527 The vast majority of detrital zircon ages in the sample of the Murtoi Fm. correspond to the
21
22 528 age of the volcanic rocks of the Khambin Ridge [bordering the basin to the West](#). There are almost
23
24 529 no zircons with ages corresponding to the volcanic rocks of the Monostoy Ridge in the sample.
25
26 530 These two results suggest that most of the topographic relief was mainly localized to the West,
27
28 531 further suggesting that the subsidence of the Gusinoozersk Basin at the initial stage was mainly
29
30 532 controlled by the Khambin Fault. The basin thus initially developed as a west-tilted (actual
31
32 533 reference frame) semi-graben (Fig. 9A). By this time, the predominant deposits were proximal
33
34 534 deposits from braided rivers draining the Khambin Ridge. In the overlying formations, represented
35
36 535 by fine-grained material, there is only minor amount of zircons with ages matching the Khambin
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38 536 volcanic rocks (see Fig. 6B, C). However, these samples contain a zircon age population consistent
39
40 537 with the age range of the Early Jurassic bimodal association, identified within the Monostoy Ridge
41
42 538 to the East (Yarmolyuk et al., 2000) (see Fig. 2). The absence of “monostoy” zircons in the basal
43
44 539 Murtoi Fm. and their presence in the Lower Selenga Sfm. and Kholboldzhin Fm. indicate the
45
46 540 formation of a positive relief to the East. This suggests an activation of the Monostoy normal **Fault**
47
48 541 **fault** later than the accumulation time of the Murtoi Fm. (Fig. 9B). The beginning of the subsidence
49
50 542 of the eastern side of the basin was accompanied by simultaneous erosion of the Monostoy Ridge.
51
52 543 This is also supported by the deposition of the coarse-grained “Monostoy” facies sediments,
53
54 544 starting from the Lower Selenga Sfm. and higher along the section, which facially replaced coal-

1
2 545 bearing deposits (Skoblo et al., 2001) (see fig. 3 and 9B). Since the age of the Lower Selenga Sfm.,
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4 546 according to the youngest zircon in the sample, is younger than ~116 Ma, it can be argued that the
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6 547 Monostoy Fault began to control the subsidence of the basin not earlier than this time. As in the
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8 548 case of the Murtoi Fm., the age is estimated from a single grain and should be taken with caution.
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10 549 The next young zircon has an age of ~171 Ma (Supplementary Data, Tables S2), which is
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12 550 obviously older than the age of the underlying Murtoi Fm. The absence of a sufficient amount of
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14 551 young zircons, corresponding to the age of sedimentation of the Selenga Fm., is possibly related
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16 552 to the mafic composition of volcanism characteristic of this time (Vorontsov et al., 2016). Thus,
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18 553 we rely on the only obtained date of ~116 Ma to characterize the age of the Lower Selenga Sfm.,
19
20 554 but at the same time we assume that the beginning of its deposition may be older, but not older
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22 555 than ~130 Ma. Since the thickness of the sediments in the basin is not constant (there is a trend
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24 556 towards an increase in thickness from the western to the eastern side (Bulnaev, 2006)), the
25
26 557 Monostoy Fault most probably played a major role in the second stage of the development of the
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28 558 basin, which started with the beginning of the accumulation of the Selenga Fm. (Fig. 9).

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34 559 The Khambin and Monostoy faults are trending obliquely to the direction of the Buteel
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36 560 metamorphic core complex, and their activation is not directly related to its tectonic exposure.
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38 561 However, the coincidence in time between the onset of active subsidence in the Gusinozersk
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40 562 Basin and the exhumation of the Buteel core complex suggest that they interacted structurally
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42 563 during a single process of crustal extension. The Khambin Fault participates to the Dzhida-Vitim
43
44 564 structural suture (see fig. 1B for location), which is the boundary between the regions of Late
45
46 565 Proterozoic Baikalian and Early Paleozoic Caledonian folding (Luchitsky, 1975). The Mesozoic
47
48 566 reactivation of the Dzhida-Vitim structure has been evidenced along its entire length. It controlled
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50 567 the development of the Dzhida-Vitim depression zone, represented by a chain of Mesozoic
51
52 568 depressions, which include the Gusinozersk Basin. Cretaceous reactivation has also been
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54 569 recorded along the Primorsky structural suture in the neighbouring Baikal region (see fig. 1B for
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56 570 location). The apatite fission track data from the Primorsky Ridge and the Olkhon block show

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2 571 rapid exhumation at ~~120~~140–140-120 Ma along the Primorsky suture (Van der Beek et al., 1996;
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4 572 Jolivet et al., 2009). Thus, during the Cretaceous extension, large inherited structures were
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6 573 activated. The basins of Transbaikalia were formed both in conjunction with the exhumation of
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8 574 metamorphic core complexes and mainly located along reactivated structural sutures. While
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10 575 middle to lower crust was exhumed to the surface within the metamorphic core complexes, the
11
12 576 probably Cretaceous basins developed along listric faults rooting in the ductile decollement zone
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14 577 at depth (Wernicke, 1981; Donskaya et al., 2008; Mazukabzov et al., 2011).

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18 578 The basal Murtoi Fm. is composed mainly of poorly sorted conglomerates, which we
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20 579 interpret as representing rapid erosion linked to the active subsidence of the depression at the initial
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22 580 stage and the formation of alluvial fans at the foot of the Khambin Ridge (see fig. 9A). The remote
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24 581 provinces located to the south of the basin also took a small part in the sedimentation during that
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26 582 time – the rivers started transporting clastic material from the Buteel metamorphic core complex.
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28 583 A modern analogue of such rivers could be the Selenga River, whose catchment includes this
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30 584 region. The Selenga River flows to the northeast, passing near the Gusinozersk Basin through the
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32 585 Monostoy Ridge, and flows into Lake Baikal (see fig. 1B). Among the detrital zircons extracted
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34 586 from modern deposits of the Selenga River Delta (Ivanov et al., 2016), some display U-Pb ages
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36 587 corresponding to the age of syenites of the Burgutuy massif of the Buteel metamorphic core
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38 588 complex. We thus assume that during the accumulation of the Gusinozersk Basin such a river
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40 589 flowed through the basin towards the Siberian Craton, unloading sediments transported from the
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42 590 southern provinces within the basin. An increase in the contribution of the southern sources up the
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44 591 section indicates either that they have become more eroded or that local sources have decreased.

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48 592 Fine-grained sediments of the Selenga and Kholboldzhin Fms. (sandstones, siltstones,
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50 593 mudstones with interlayers of coals) indicate that, starting from the middle Aptian (considering
51
52 594 that the ~116 Ma zircon age corresponds to the lower limit of sedimentation), Western
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54 595 Transbaikalia evolved in a relatively calm tectonic regime, characterized by the slow subsidence
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56 596 in the various basins and the continuing denudation of not yet completely eroded ridges. At that
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1
2 597 time, the Monostoy Fault still played the main role in the subsidence of the depression. This is
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4 598 confirmed by the deposition of the "Monostoy" conglomerates at the foot of the Monostoy Ridge,
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6 599 laterally replacing the fine-grained sediments of the Selenga and Kholboldzhin fms, and by the
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8
9 600 occurrence of zircons derived from volcanic rocks located in the Monostoy Ridge. The
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11 601 "Monostoy" facies corresponds to the proximal parts of the alluvial fans deposited by the rivers
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13 602 that were draining the Monostoy Ridge. In the central part of the basin, distal alluvial plain
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15 603 sediment facies accumulated in fluvial and lacustrine-swamp environments (see fig. 9B). The
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17 604 decrease in the subsidence rate of the depression and smoothing of the topography led to the
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19 605 overfilling of the depression with sediments, swamping and peat formation, which gave rise to the
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21 606 formation of coal.
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25 607 Thus, by the end of the Early Cretaceous, the topography finally flattened out and the
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27 608 Gusinozersk Basin ceases to be an area of sedimentation. However, it seems that the process of
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29 609 collapse of the Mongol-Okhotsk orogen does not end there, and the extension is shifted closer to
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31 610 the boundary of the Siberian Craton to the area of the Baikal rift system. For example, Van der
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33 611 Beek et al. (1996) and Jolivet et al. (2009) based on apatite fission track data showed the
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35 612 reactivation of the Primorsky and Barguzin faults of the Baikal rift system (see Fig. 1 for location)
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37 613 in the Late Cretaceous and interpreted it as a continuation of postorogenic extension in
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39 614 Transbaikalia.
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44 616 **5. Conclusions**

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46
47 617 Geochronological dating of sedimentary and igneous rocks of the Gusinozersk Basin
48
49 618 made it possible to clarify the age of paleogeographic events associated with the collapse of the
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51 619 Mongol-Okhotsk orogen in Western Transbaikalia. U/Pb (LA-ICP-MS) dating of detrital zircons
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53 620 from sedimentary deposits and $^{40}\text{Ar}/^{39}\text{Ar}$ dating of intruding volcanic rocks showed that the
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56
57 621 formation of the Cretaceous basins of Transbaikalia began around ~~130-136~~ 136-130 Ma. It is
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1
2 622 related to the main episode of extension associated with the exhumation of metamorphic core
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4 623 complexes.

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6 624 The lowest coarse-clastic Murtoi Fm. characterizes the rapid subsidence of the basin and
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8 625 the predominance of proximal sediment sources. The provinces located south of the Gusinozersk
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10 626 Basin also made a contribution to sedimentation indicating the rise of a positive topography
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12 627 associated with the exhumation of the metamorphic core complexes.

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15 628 From the middle of the Aptian, Western Transbaikalia developed in a relatively calm
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17 629 tectonic regime, as evidenced by fine-grained deposits of the Selenga Sfm. and Kholboldzhin Fm.
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19 630 Within the general pattern of a significant smoothing of the topography, the exposed metamorphic
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21 631 cores complexes continued to be a source of sediments for the basins of Transbaikalia.

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23
24 632 The subsidence of the Gusinozersk Basin was controlled by two side faults: at an early
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26 633 stage, by the Khambin Fault, and at a later stage, by the Monostoy Fault. The Khambin Fault is an
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28 634 inherited Paleozoic structure reactivated during Cretaceous extension. The basins of Transbaikalia
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30 635 were formed both in conjunction with the exhumation of metamorphic cores complexes and
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32 636 reactivated structural sutures.

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35 637 New data on dinosaur fauna and palynology, together with the dating of host deposits,
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37 638 made it possible to correct the age of faunal assemblages in Western Transbaikalia, which is very
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39 639 important for biostratigraphic correlations in various regions of Central Asia. ~~The currently known~~
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41 640 ~~data on the palaeoenvironment of the Mogoito locality suggest that the climate was moderately~~
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43 641 ~~warm but too cold for thermophilic crocodyliforms. The onset of formation of the Gusinozersk~~
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45 642 ~~Basin coincided with the global cooling Weissert Event. During that period the temperate climate~~
46
47 643 ~~prevailing in Transbaikalia was favorable to the existence and reproduction of dinosaur, turtles~~
48
49 644 ~~and choristoderes, but not suitable for crocodiles. The time of the onset of sedimentation in the~~
50
51 645 ~~Gusinozersk Basin probably coincides with the Weissert Event ~133 million years ago marking~~
52
53 646 ~~a profound global cooling that punctuated the Early Cretaceous greenhouse (Cavalheiro et al.,~~
54
55 647 ~~2021; Scotese et al., 2021).~~
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648

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2 28 proximal sediment sources. Distal provinces also made a contribution to sedimentation indicating
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4 29 the rise of a positive topography characterizing the exhumation of the metamorphic core
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6 30 complexes. Overlying fine-grained formations indicate a significant smoothing of the topography,
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8 31 suggesting that from middle Aptian, Western Transbaikalia developed in a relatively calm tectonic
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10 32 regime. We also show that the basins of Transbaikalia were formed both in conjunction with the
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12 33 exhumation of metamorphic cores complexes and reactivated structural sutures. Revised data on
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14 34 dinosaur fauna and palynology, together with the dating of host deposits, provide insights on the
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16 35 Early Cretaceous paleoenvironmental evolution.
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23 37 **Keywords:** U–Pb detrital zircons dating; sediment source-to-sink analysis; topographic evolution;
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25 38 Western Transbaikalia.
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30 40 1. Introduction

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32 41 The Mesozoic topographic and environmental evolution of Transbaikalia was largely driven by
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34 42 the tectonic evolution of the Mongol-Okhotsk orogenic belt (see fig. 1A for location). The belt
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36 43 was formed as a result of the closure of the Mongol-Okhotsk Ocean which extended between the
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38 44 Siberian and Mongolian-North China continents from the Late Paleozoic to the Mesozoic
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40 45 (Zonenshain et al., 1990; Sengör and Natal'in, 1996; Yin and Nie, 1996; Zorin, 1999). Most
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42 46 geodynamic models indicate a scissor-like closure of the ocean from West to East from the
43
44 47 Permian to the Middle Jurassic (Zonenshain et al. 1990; Nie et al., 1990; Nie, 1991; Yin and Nie,
45
46 48 1993; 1996; Zorin et al., 1998; Davis et al., 1998; Gordienko, Kuzmin, 1999; Zorin, 1999; Darby
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48 49 et al., 2001; Parfenov et al., 2003; Donskaya et al., 2013; Demonterova et al., 2017; Sorokin et al.,
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50 50 2020; Wang et al., 2022 and others). Recent detrital zircon U-Pb data from marine and continental
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52 51 deposits along the Mongol-Okhotsk suture showed that the last stage of oceanic closure was
53
54 52 segmental. Some terranes in the central part of the ocean accreted to the Siberian continent 5–10
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56 53 Ma later than in the western and eastern parts (Guo et al., 2017; Arzhannikova et al., 2022).
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2 54 Although this geodynamic event has been widely studied, the topographic evolution of the
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4 55 Mongol-Okhotsk belt is still poorly understood. Widespread magmatism and thrusting related to
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6 56 subduction and collision suggested that the Mongol–Okhotsk belt formed as a plateau-like uplift
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9 57 (Zorin, 1999). Paleomagnetic data obtained from the Mesozoic deposits of Southeastern Siberia
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11 58 and Northern Mongolia indicate left-lateral strike-slip motion along the Mongol-Okhotsk suture
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13 59 zone during and after the collision, caused by the clockwise rotation of the Siberian continent
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15 60 (Parfenov et al., 2001; Metelkin et al., 2004, 2010). Yang et al. (2015) proposed that this major
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17 61 left-lateral strike-slip motion triggered the gravitational collapse of the thickened upper crust,
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19 62 leading to the development of rift basins. Detrital zircon dating and sedimentology study in the
20
21 63 Tugnu Basin, one of the oldest Mesozoic basins of Transbaikalia (see fig. 1B for location),
22
23 64 revealed rapid geodynamic changes from collision to widespread rifting at about 168 Ma
24
25 65 (Arzhannikova et al., 2020). The paleogeographic reconstruction showed that the region was
26
27 66 subjected to several stages of compression and extension associated with an oblique collision that
28
29 67 took place at different times in the Middle and Upper Jurassic in different regions of Transbaikalia
30
31 68 (Yang et al., 2016; Arzhannikova et al., 2020; 2022). The main stage of collapse of the Mongol-
32
33 69 Okhotsk orogen is associated with the exhumation of metamorphic core complexes and the
34
35 70 formation of rift basins, widely distributed over Transbaikalia, North Mongolia (Fig. 1B), and
36
37 71 within the North China Craton. This widespread, highly distributed extension phase occurred
38
39 72 between 138 Ma and 110 Ma, with a peak at 130–125 Ma (Zheng et al., 1991; Sklyarov et al.,
40
41 73 1997; Zorin et al., 1997; Zorin, 1999; Donskaya et al., 2008; Daoudene et al., 2013, 2017; Wang
42
43 74 et al., 2011, 2012; Ivanov et al., 2015; Zhang et al., 2019). Numerous paleontological,
44
45 75 paleobotanical, lithofacies and biostratigraphic studies have been carried out from the sedimentary
46
47 76 deposits of the Transbaikalia rift basins (e.g. Martinson, 1961; Kolesnikov, 1961; 1964; Otchirov,
48
49 77 1964; Serdobolskaya and Kozubova, 1976; Skoblo et al., 2001; Jolivet et al., 2017; Arzhannikova
50
51 78 et al., 2018). However, the absence of absolute ages for the sedimentary series did not allow to
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53 79 accurately characterize the regional topographic and environmental evolution.
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1
2 80 The Cretaceous basins of Transbaikalia are nonetheless key objects to study the destruction
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4 81 of the Mongol-Okhotsk orogen and the corresponding paleoenvironmental evolution. These basins
5
6 82 represent a unique record of the Cretaceous fauna, flora, climate and topography of this huge
7
8 83 region. One of the key depressions, where extensive sedimentary sections of Cretaceous deposits
9
10 84 have been preserved, is the Gusinozersk Basin of Western Transbaikalia (see fig. 1B for location).
11
12 85 Sediments of this depression are well characterized by fossil fauna. Bonebeds containing the
13
14 86 remains of dinosaurs and other vertebrates were found in the sediments of the basal Murtoi
15
16 87 Formation. Based on the correlation of vertebrate faunas, the age of the sediments was estimated
17
18 88 ranging from Late Berriasian to Middle Aptian (Dmitriev, 1960; Nessonov and Starkov, 1992;
19
20 89 Averianov et al, 2003), thus from ~127 to 120 Ma (here and further the stratigraphic age is
21
22 90 established according to www.stratigraphy.org assessed on 30th May 2022). However, later studies
23
24 91 of the fauna suggested that deposits in the Gusinozersk Basin could begin to accumulate earlier,
25
26 92 starting from the Late Berriasian – Valanginian (Skoblo et al., 2001) (~140 Ma) or Late
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28 93 Valanginian – Barremian (Averianov et al., 2022) (~133–125 Ma). Constraining the time span in
29
30 94 the geological record of well-preserved sediments is key to determine the paleoenvironment of the
31
32 95 region, as well as the age and correlation of non-marine vertebrates of the Early Cretaceous in
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34 96 Transbaikalia, Mongolia, and China.

35
36 97 The objective of this study was to bracket the age of the sedimentary series of the
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38 98 Gusinozersk Basin based on U/Pb (LA-ICP-MS) dating of detrital zircons and ⁴⁰Ar/³⁹Ar dating
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40 99 of an intruding dike. Carrying out absolute dating made it possible to clarify the age of the
41
42 100 paleogeographic events associated with the collapse of the Mongol-Okhotsk orogen, as well as to
43
44 101 correct the age of faunal complexes in Western Transbaikalia. This last point represents a leap
45
46 102 forwards to biostratigraphic correlations in various regions of Central Asia.

47
48 103 A recent revision of the dinosaur fauna (Averianov et al., 2022) has made it possible to
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50 104 take a fresh look at the faunal list of the complex of fossil vertebrates in the Gusinozersk Basin.
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2 105 This, together with new data on age and paleogeography in this study, provides a more complete
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4 106 picture of the Early Cretaceous paleoenvironments of Western Transbaikalia.
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8 9 108 **2. Geological setting**

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11 109 The Gusinozersk Basin is a Cretaceous NE-SW oriented depression bounded to the NW
12
13 110 and SE by the Khambin and Monostoy ridges, respectively (Fig. 2). The Gusinozersk Basin was
14
15 111 first described as a typical graben (Luchitsky, 1975). According to Leonov (1983), two
16
17 112 synsedimentary tectonic structures, the Khambin and Monostoy faults, were involved in the
18
19 113 formation of the basin, and the onset of sedimentation was associated with the activation of the
20
21 114 Khambin Fault (see fig. 2 for location). Later, Bulnaev (2006) established this depression as
22
23 115 monoclinical, formed due to unilateral synsedimentary subsidence along the Monostoy Fault, which
24
25 116 runs along the eastern flank of the basin (see fig. 2 for location). Indeed, the thickness of sediments
26
27 117 in the depression is not constant, increasing from the western edge to the East. This indicates that
28
29 118 the role of the Monostoy Fault in the development of the basin was predominant (Bulnaev, 2006).
30
31 119 Below we present a description of the igneous complexes within the Khambin and Monostoy
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33 120 ridges, as potential sediment sources, as well as a description of the sedimentary deposits of the
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35 121 Gusinozersk Basin.
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40 41 122 **2.1. Igneous complexes of the Khambin and Monostoy ridges**

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43 123 The Khambin Ridge, framing the Gusinozersk Basin to the west, is composed of two
44
45 124 igneous complexes. The “Ichetui” bimodal volcanics are identified in the southern part of the ridge
46
47 125 (see fig. 2). They are also distributed within several grabens of Western Transbaikalia and
48
49 126 composed of trachybasalts, trachyandesites, trachydacites and trachyrhyodacites. The “Ichetui”
50
51 127 volcanic rocks have been dated by different geochronological methods from 168 to 145 Ma in
52
53 128 different places of Western Transbaikalia (Gordienko et al., 1997; Ivanov et al., 1995; Vorontsov
54
55 129 et al., 1999; Andryushchenko et al., 2010; Arzhannikova et al., 2018). Specifically, for the
56
57 130 Khambin Ridge, two dates were obtained with ages of ~159 and ~156 Ma (Andryushchenko et al.,
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1
2 131 2010). The northern part of the Khambin Ridge is characterized by the Sogotinsk igneous complex
3
4 132 (see fig. 2). Three phases of intrusion are distinguished within the complex: monzonites and quartz
5
6 133 monzonites; syenites, quartz syenites and granosyenites; and moderately alkaline granites and
7
8 134 leucogranites. Geochronological dating of the Sogotinsk complex by the K-Ar method provided
9
10 135 an age range of 271–220 Ma for the granitoids, while the Rb-Sr method gave an age range of 287–
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12 136 267 Ma (Platov et al., 2013).

13
14
15 137 The Monostoy Ridge is mainly composed of Paleozoic meta-sedimentary series, locally
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17 138 intruded by the Triassic granitoids of the Malo-Kunaley complex and some Early Jurassic bimodal
18
19 139 association (Fig. 2). The Malo-Kunaley complex is represented by peralkaline granites,
20
21 140 granosyenites and alkaline syenites. A Late Triassic age of 220–212 Ma was determined for the
22
23 141 Malo-Kunaley granites from whole rock Rb-Sr and zircon U-Pb analysis (Yarmolyuk et al., 2000;
24
25 142 Litvinovsky et al., 2001; Reichow et al., 2010). The Early Jurassic bimodal association is
26
27 143 widespread in Western Transbaikalia. Within the Monostoy Ridge it is composed of a thick (over
28
29 144 2000 m) bimodal volcanic sequence (trachybasalts, trachyandesite-basalts, alkaline trachydacites)
30
31 145 with an age, determined by whole rock Rb-Sr analysis, of ~194 Ma (Yarmolyuk et al., 2000).

32 146 **2.2. Sedimentary deposits of the Gusinozersk Basin**

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34
35 147 The age of the sedimentary deposits is debated. The main studies were carried out in the
36
37 148 1950-1960s. Various complexes of freshwater mollusks characteristic of the Middle, Upper
38
39 149 Jurassic - Lower Cretaceous were found in different parts of the sedimentary section of the basin
40
41 150 (e.g. Martinson, 1955). According to Otchirov (1964), sedimentation began in the Gusinozersk
42
43 151 Basin from the Early Jurassic and continued up to the upper Lower Cretaceous. Kolesnikov (1961;
44
45 152 1964), based on lithological, paleontological and geological data, attributed the entire section of
46
47 153 the Mesozoic continental deposits to the Middle Jurassic - Lower Cretaceous. Based on geological
48
49 154 mapping, Komarov (1962) divided the stratigraphic section, from base to top, into the Sanga,
50
51 155 Selenga, Bain-Zurkhen and Kholboldzhin Fms. All formations were described as conformable and
52
53 156 span from the Upper Jurassic to the Lower Cretaceous (Fig. 3).

1
2 157 Subsequently, a rich collection of fossil mollusks, ostracods and plants, as well as
3
4 158 fragmentary remains of bones and teeth of dinosaurs was collected (Scoblo, 1967). This new
5
6 159 collection, as well as geological drilling data for coal exploration, raised disagreements on the
7
8 160 Mesozoic stratigraphy of the Gusinozersk Basin, leading to different interpretations of the
9
10 161 complex geological structures of this region. The scheme proposed by Scoblo (1967) differs
11
12 162 significantly from those of Martinson (1961), Kolesnikov (1961; 1964) or Otchirov (1964). In
13
14 163 particular, it suggests a complete absence of Middle and Upper Jurassic sediments in the
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16 164 Gusinozersk Basin. Later, numerous fossil findings made it possible to expand the lists of ancient
17
18 165 fauna and flora and significantly correct the stratigraphy and distribution of fossil organisms
19
20 166 (Scoblo et al., 2001). In our work, we adhere to the stratigraphic scheme published in (Scoblo et
21
22 167 al., 2001), which is best characterized by fossil fauna. The Gusinozersk series are subdivided into
23
24 168 four formations (bottom-up) (Fig. 3):

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26
27 169 1. The Murtoi Fm. (K_{1mr}) (analogous to the lower sub-formation of the Sanga Fm.
28
29 170 according to Komarov (1962), (Fig. 3)), is 300-450 m thick and occurs along the western side of
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31 171 the Gusinozersk Basin, at the foot of the Khambin Ridge. The Murtoi Fm. rests on the underlying
32
33 172 Middle and Upper Jurassic volcanic rocks through an erosional unconformity. It is composed of
34
35 173 interbedded conglomerates, gravelstones, sandstones and silicic volcanic rocks. Up section, the
36
37 174 conglomerates become finer, and the number and thickness of the sandstone interlayers increase.
38
39 175 The sorting and rounding of pebbles increase up section, which is interpreted as a decrease in
40
41 176 fluvial-environment deposits and a correlative increase in lacustrine deposits (Skoblo et al., 2001).
42
43 177 In the Mogoito locality (see fig. 2) the Murtoi Fm. contains various fossil bivalves, gastropods,
44
45 178 scattered fragmental remains of vertebrates such as palaeonisciform, acipenceriform and
46
47 179 teleostean actinopterygians, macrobaenid turtles, lizards, various ornithischian and saurischian
48
49 180 dinosaurs, pterosaurs, birds, and eutherian mammals (Skoblo et al., 2001; Averianov and
50
51 181 Skutschas, 2001; 2009; Averianov et al, 2003; Skutschas, 2008). New data on fauna and
52
53 182 palynology from the Mogoito locality make it possible to estimate the age of the formation as Late
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1
2 183 Valanginian – Barremian (~133–125 Ma), although some of the data are quite contradictory and
3
4 184 require further clarification (Averianov et al., 2022).

5
6 185 2. The Ubukun Fm. (K_1 ub) (analogous to the upper sub-formation of the Sanga Fm.
7
8 186 according to Komarov (1962), (Fig. 3)) is 300-450 m thick and characterized by deep-lake
9
10 187 sediment facies. Mudstones are widespread in the lower part of the formation, interbedded with
11
12 188 siltstones and fine-grained sandstones higher-up in the section. Sandstones with small coal lenses
13
14 189 dominate the upper part of the section. The fossil fauna (mostly ostracods) is exclusively
15
16 190 limnophilic, characteristic of a lake at least 50 m deep (Skoblo et al., 2001). Sandy facies with coal
17
18 191 lenses in the upper part of the formation indicate shallowing of the lake and development of
19
20 192 swamps. The biostratigraphic age of the Ubukun Fm. is determined as Hauterivian (132.6–129.4
21
22 193 Ma) (Skoblo et al., 2001).

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26
27 194 3. The Selenga Fm. (K_1 sl) forms the lower part of the coal-bearing strata of the
28
29 195 Gusinozersk series, and shows the greatest regional distribution. It is characterized by
30
31 196 transgression-regression cycles and divided into two sub-formations. The Lower Selenga sub-
32
33 197 formation (K_1 sl₁) corresponds to the Selenga Fm., and the Upper Selenga sub-formation (K_1 sl₂)
34
35 198 corresponds to the Bain-Zurkhen Fm. according to Komarov (1962), (Fig. 3)). The Lower Selenga
36
37 199 Sfm., with a total thickness of up to 600 m is represented by interbedded gravelstones, sandstones,
38
39 200 siltstones, mudstones, and coal. The grain size is decreasing up section. The sub-formation is
40
41 201 characterized by three ostracod horizons. The Upper Selenga Sfm., up to 500 m thick, lacks
42
43 202 gravelstones and is dominated by finer-grained sediments. The number and thickness of coal seams
44
45 203 in the Upper Selenga Sfm. is greater than in the Lower Selenga Sfm. Different parts of the section
46
47 204 display carbonaceous sandy shale layers (“paper” oil shale) with fish, pelecypod and ostracod
48
49 205 horizons. The sub-formation is also characterized by various bivalves and gastropods. The
50
51 206 biostratigraphic age of the entire Selenga Fm. is determined as Hauterivian-Barremian (~130 Ma)
52
53 207 (Skoblo et al., 2001).

1
2 208 4. The Kholboldzhin Fm. (K_1 hl) forms the upper part of the Mesozoic deposits in the
3
4 209 Gusinozersk Basin (Fig. 3). It has a thickness of up to 1200 m and conformably overlies the
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6 210 Selenga Fm. The deposits are represented by polymictic arkose sandstones, siltstones and coal.
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8
9 211 The coal occurrence in this formation is the highest in the Gusinozersk Basin, displaying more
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11 212 than 16 coal seams with a thickness of 2-4 to 53 m. The deposits contain ostracods and small
12
13 213 bivalves. The biostratigraphic age of the Kholboldzhin Fm. is determined as Barremian-Aptian
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15 214 (~129.4–113 Ma) (Skoblo et al., 2001).

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17
18 215 The Monostoy foothill series form a separate stratigraphic unit along the foot of the
19
20 216 Monostoy Ridge and is represented by colluvions, conglomerates, breccias, gravelstones with
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22 217 sandstone interbeds. Drilling data show that sediments of this series are laterally correlated to fine-
23
24 218 grained sediments in the basin, starting from the Lower Selenga Sfm. (Bulnaev, 2006; Skoblo et
25
26 219 al., 2001) (Fig.3). This indicates that, starting from the time of the accumulation of the Lower
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28 220 Selenga Sfm., the Monostoy Fault played the main role in the subsidence of the basin.

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30
31 221 The correlation of sections in several areas of the Gusinozersk Basin is based on the
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33 222 complexes of fauna (especially ostracods and mollusks) and takes into account all the geological
34
35 223 and structural data. Though numerous intra-formation erosion surfaces are exposed, the overall
36
37 224 stratigraphy seems conformable, without major erosion lags. Biostratigraphically, this is
38
39 225 confirmed by the succession of faunal complexes and the stability of the plant association
40
41 226 throughout the Lower Cretaceous. The composition of the flora from individual formations and
42
43 227 sub-formations indicates that they evolved under similar paleoenvironmental conditions (Skoblo,
44
45 228 1967; Skoblo et al., 2001). At the same time, the variations in sediment facies assemblages and
46
47 229 depositional environments indicate different dynamics of basin subsidence.

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49
50 230 The discussion above clearly shows that the age and stratigraphy of the deposits of the
51
52 231 Gusinozersk Basin have been debated for many decades. So far, no geochronological data have
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54 232 been published on the Late Mesozoic sedimentary deposits of the basin, nor data on the evolution
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56 233 of sediment sources. Such data are nonetheless necessary to fully constrain the onset of formation

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2 234 of the Cretaceous basins in Transbaikalia and assess the morphostructural and paleoenvironmental
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4 235 evolution associated with the collapse of the Mongol-Okhotsk orogen.
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237 **3. Detrital zircon U-Pb (LA-ICP-MS) and igneous rocks $^{40}\text{Ar}/^{39}\text{Ar}$ dating**

238 **3.1. Sampling sites**

239 In this study, we selected samples from three key formations of the Gusinozersk Basin
240 and performed U-Pb (LA-ICP-MS) analysis of detrital zircons to clarify the depositional age and
241 determine the evolution of the source-to-sink pattern. The samples were taken from the basal
242 Murtoi Fm., the Lower Selenga Sfm. and the Kholboldzhin Fm, covering the entire section of the
243 Cretaceous deposits (Figs. 2, 3).

244 The Murtoi Fm. was sampled from an outcrop located near the Murtoi Valley
245 ($\text{N}51^{\circ}09.745'$; $\text{E}106^{\circ}13.630'$) (Fig. 4, sample Gus-17-1, see Fig. 2 for location). The deposits are
246 poorly sorted conglomerates composed of largely self-supported, moderately to well-rounded
247 pebbles and cobbles up to 20 cm in size with a limited sandy matrix. Pebbles and cobbles consist
248 mainly of intermediate and felsic volcanic rocks with mafic inclusions. The deposits are interpreted
249 as proluvial-alluvial facies from braided rivers. Sample Gus-17-1, collected for U-Pb (LA-ICP-
250 MS) detrital zircon dating was taken from the sandy matrix (Fig. 4C).

251 Within the studied outcrop, the conglomerates are intruded by the Murtoi dike belonging
252 to the Khurai-Baiba dike complex (Komarov, 1962) (Fig. 4A, B). The apparent width of the dike
253 is 9 m. The dike has a lamprophyric composition with inclusions of granitoid xenoliths (Khubanov
254 et al., 2017). There are at least three magmatic intrusion phases, similar in composition but
255 different in degree of crystallization (Andryushchenko et al., 2010). The dike was previously dated
256 by Rb-Sr and K-Ar methods, which yielded ages of 117 ± 6 Ma and 122 Ma (without stated
257 uncertainty), respectively (Litvinovsky et al., 1989). To clarify the age of the intrusion within the
258 studied outcrop and to establish the upper limit of the age of the sampled sedimentary unit, a
259 sample Mur-17-1 was taken from the dike for $^{40}\text{Ar}/^{39}\text{Ar}$ analysis.

1
2 260 The Lower Selenga Sfm. is represented by a 90-meter thick section in the undercut of a
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4 261 road, NW of the basin (N51°16.491'; E106°22.275') (Fig. 5A, see position of sample Gus-14-6 on
5
6 262 fig. 2 for location) (Jolivet et al., 2017). The deposits are tilted westward. The lower (eastern) part
7
8 263 of the section is represented by medium- and fine-grained light grey sandstones alternating with
9
10 264 siltstones and rare thin coal interlayers. In the upper part of the section, the coal layers become
11
12 265 thicker (up to 1 m) and are interbedded with siltstones and fine-grained sandstones. According to
13
14 266 Martinson (1961) and Jolivet et al. (2017) such deposits characterize a subsiding, wet, densely-
15
16 267 vegetated alluvial plain environment. The change from coarse-grained to fine-grained deposits
17
18 268 with an increase in the proportion of coals indicates a retrogradation trend and a transition to a
19
20 269 lacustrine depositional environment. The fine-grained deposits and the occurrence of coal
21
22 270 interlayers suggest a low-relief topography in the area of the basin and a relatively low input of
23
24 271 clastic sediments. A sample for U-Pb (LA-ICP-MS) dating of detrital zircons (Gus-14-6) was
25
26 272 collected from a medium-grained sandstone at 61 m from the base of the logged section (Fig. 5A).

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31 273 The Kholboldzhin Fm. is represented by a 70-meter thick section within the Gusinozersk
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33 274 coal deposit on the eastern shore of Lake Gusinoe (N51°09.284'; E106°25.795') (see position of
34
35 275 sample Gus-14-1 on fig. 2 for location) (Jolivet et al., 2017). The section displays interbedded grey
36
37 276 siltstones with plant remains, rare interlayers of fine- to medium-grained sandstone, and coal
38
39 277 seams up to 3 m thick (Fig. 5B, C). This facies assemblage is interpreted as lacustrine to marsh
40
41 278 depositional environments. The upper ~20 m of the section are represented mainly by fine- to
42
43 279 medium-grained sandstones with a calcareous and clay cement, interpreted as meandering river
44
45 280 facies (Jolivet et al., 2017). A sample for detrital zircon dating (Gus-14-1) was collected from one
46
47 281 of the fine-to-medium-grained sandstone interbeds in the lower part of the section (23 m from
48
49 282 bottom) (Fig. 5B).

283 3.2. Analytical methods and results

284 Sample preparation for detrital zircons analysis was carried out at the Centre for
285 Geodynamics and Geochronology of the Institute of the Earth's Crust SB RAS. U-Pb (LA-ICP-

MS) analysis was made at the Analytical center of mineralogical, geochemical and isotope studies at the Geological Institute, SB RAS. The sample preparation and analytical procedures are the same as described in Arzhannikova et al. (2020). The isotopic ratios measurement technique is described in detail in Khubanov et al. (2016) and Buyantuev et al. (2017). For this study, more than 100 zircon grains were selected from each sample, with no differentiation of size (the size of the analyzed grains varied from 60 μm to 180 μm) or morphology. U-Pb analysis was performed using an ICP-MS Element XR (ThermoFisher Scientific) coupled to an UP-213 laser (New Wave). Zircons 91500 (1065 Ma) (Wiedenbeck et al., 1995), Plešovice (337 Ma) (Slama et al., 2008), and GJ-1 (608.5 Ma) (Jackson et al., 2004) were used as external standards. The relative errors in the measurement for isotope ratios in the reference standards varied within ranges of 1%–2.3% for $^{208}\text{Pb}/^{232}\text{Th}$, 2.1%–2.6% for $^{207}\text{Pb}/^{206}\text{Pb}$, 1.1%–2.6% for $^{206}\text{Pb}/^{238}\text{U}$ and 2%–2.5% for $^{207}\text{Pb}/^{235}\text{U}$. Analytical results were processed using the GLITTER (Griffin et al., 2008) software. Only data with a concordance >90% were taken into account in the interpretation. The abundance histograms and probability density curves for each sample were plotted for $^{206}\text{Pb}/^{238}\text{U}$ ages with 2σ analytical uncertainty using the Dezirteer software (Powerman et al., 2021). Most U-Pb ages cluster below 400 Ma with few outliers showing older ages (Supplementary Data, Tables S1-S3). Therefore, we used only grains younger than 400 Ma to plot the diagrams (Fig. 6).

$^{40}\text{Ar}/^{39}\text{Ar}$ dating was carried out at the Centre for Geodynamics and Geochronology of the Institute of the Earth's Crust SB RAS using an ARGUS VI mass spectrometer coupled to a double-vacuum resistance oven. The age was calculated relative to the BERN4M standard with an age of 18.885 ± 0.097 Ma, which makes it possible to directly compare the $^{40}\text{Ar}/^{39}\text{Ar}$ and U-Pb ages (Ivanov et al., 2017).

Ninety-one concordant U-Pb zircon ages were obtained from the basal Murtoi Fm. (sample Gus-17-1). They are statistically distributed into the following populations: 150-165, 170-185, 215-245, 250-270 and 280–300 Ma. The youngest zircon has an age of 136 ± 4 Ma (Fig. 6A; Supplementary Data, Tables S1). In the Lower Selenga Sfm. (sample Gus-14-6), 76 concordant

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2 312 U-Pb zircon ages were obtained. The main age population ranges 175–210 Ma, and is
3
4 313 complemented by a minor group with ages of 225–245 Ma and few, scattered older ages. The
5
6 314 youngest zircon present in the sample has an age of 116 ± 2 Ma (Fig. 6B; Supplementary Data,
7
8 315 Tables S2). In the Kholboldzhin Fm. (sample Gus-14-1), 103 concordant U-Pb zircon ages were
9
10 316 obtained. Zircon ages are distributed into one major population at 160–230 Ma with a main peak
11
12 317 at 191 Ma. A few older outliers are also present as in the Lower Selenga sample. The youngest
13
14 318 zircon in the sample is 160 ± 2 Ma (Fig. 6C; Supplementary Data, Tables S3).

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18 319 The $^{40}\text{Ar}/^{39}\text{Ar}$ plateau age of lamprophyre sample Mur-17-1 lamprophyres collected from
19
20 320 the Murtoi dike is 130 ± 1 Ma (Fig. 7A). The same plateau steps form an inverse isochron with
21
22 321 age of 130 ± 1 Ma and initial $^{40}\text{Ar}/^{36}\text{Ar}=285 \pm 63$. Because the initial argon isotope composition
23
24 322 is equal to the atmospheric value (~ 300), the calculation of the plateau age, which assumes the
25
26 323 atmospheric initial value, is justified. Further, we use the plateau age because it has lower
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28 324 analytical uncertainty.

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33 326 **4. Discussion**

34 327 **4.1. Age and evolution of provenance of the Gusinozersk Basin deposits**

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37 328 In sample Gus-17-1 from the Murtoi Fm. the age population of 150–165 Ma forms a
38
39 329 significant age peak (see Fig. 6A). This age range corresponds to that of the “Ichetui” bimodal
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41 330 volcanics identified in the southern part of the Khambin Ridge (see Fig. 2). The main age
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43 331 population of 215–270 Ma corresponds in age to the Sogotinsk igneous complex identified in the
44
45 332 northern part of the Khambin Ridge (see Fig. 2). The small age population of 280–300 Ma zircons
46
47 333 in this sample can be attributed to the Angara-Vitim batholith. Finally, tracing the provenance of
48
49 334 the 170–185 Ma zircons is a challenge. Almost no igneous rocks of this age have been found in
50
51 335 Western Transbaikalia or Northern Mongolia. The only dating of syenites in this range (178 ± 3
52
53 336 Ma) is situated in the Burgutuy massif of the Buteel metamorphic core complex (Mazukabzov et
54
55 337 al., 2006) (see Fig. 1B for location).

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2 338 In sample Gus-14-6 from the Lower Selenga Sfm., most zircons ages range 175–210 Ma
3
4 339 (see fig. 6B), which can be attributed to the syenites of the Burgutuy massif, as well as to the Early
5
6 340 Jurassic bimodal association, identified within the Monostoy Ridge. A small population with an
7
8 341 age of 225–245 Ma matches the age of the Sogotinsk igneous complex.

9
10
11 342 In sample Gus-14-1 from the Kholboldzin Fm., almost all zircons ages are 160–230 Ma,
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13 343 with the maximum number occurring between 160 and 200 Ma (see Fig. 6C), as in the Selenga
14
15 344 Sfm.

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17
18 345 As evidenced by the histogram of the age distribution of detrital zircons from the Murtoi
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20 346 Fm. (Fig. 6A), the contribution of proximal sources located in the Khambin Ridge in the total
21
22 347 amount of zircons is major. The mostly coarse-grained deposits suggest that most of the clastic
23
24 348 material was transported by braided rivers draining the Khambin Ridge. The minor zircon
25
26 349 population of 170–185 Ma indicates a small contribution to the sedimentation from more distant
27
28 350 provinces located to the south in the area of the Burgutuy massif of the Buteel metamorphic core
29
30 351 complex (see fig. 1B for location). In the overlying Selenga and Kholboldzhin Fms., zircons
31
32 352 brought from the Khambin Ridge are practically absent, except for a small population with an age
33
34 353 of 225–245 Ma. The main source of sediments in these formations appears to be the Monostoy
35
36 354 Ridge and the Buteel metamorphic core complex. Syn-tectonic biotite $^{40}\text{Ar}/^{39}\text{Ar}$ age and U-Pb age
37
38 355 of metamorphic zircon from the footwall of the Buteel metamorphic core complex indicate that its
39
40 356 exhumation occurred between 138 Ma and 122 Ma (Mazukabzov et al., 2011), possibly exposing
41
42 357 the 178 ± 3 Ma Burgutuy massif to erosion and providing a new sediment source for the
43
44 358 Gusinozersk Basin. A fine-grained lithology of the Selenga and Kholboldzhin Fms. sediments
45
46 359 reflects a smoothing of the topography in the region, suggesting a low-intensity tectonic regime.
47
48 360 The slow subsidence of the basin during the accumulation of the Selenga and Kholboldzhin Fms.
49
50 361 was largely compensated by sedimentation mainly occurring in lacustrine-swamp depositional
51
52 362 environments with an occasional supply of coarser alluvial material associated with erosion of the
53
54 363 sides of the basin. All formations contain a few zircons with ages of 280–330 Ma that match the

1
2 364 age of the Angara-Vitim batholith (Litvinovsky et al., 2011) located to the north of the
3
4 365 Gusinozersk Basin. Judging by the significant occurrence of Late Carboniferous–Early Permian
5
6 366 detrital U–Pb zircon ages in the Lower–Middle Jurassic deposits of the Verkhoyansk margin and
7
8 367 the Irkutsk Basin (see fig. 1B for location), the Angara–Vitim batholith region represented an
9
10 368 uplifted area up to the beginning of the Middle Jurassic (Prokopiev et al., 2008; Demonterova et
11
12 369 al. , 2017; Mikheeva, 2017). Until that time, the rivers draining the southern part of the Angara-
13
14 370 Vitim batholith transported the clastic material southward to the Mongol-Okhotsk continental
15
16 371 margin. The closure of the Mongol-Okhotsk Ocean in the region of Western Transbaikalia at the
17
18 372 Early and Middle Jurassic boundary led to a reorganization of the drainage network and a change
19
20 373 in the direction of transport of sedimentary material to the north (Arzhannikova et al., 2020). The
21
22 374 occurrence of zircon ages corresponding to sources both north and south of Western Transbaikalia
23
24 375 in one sample indicates recycling of sediments from previous deposits (Yang et al., 2013), as it
25
26 376 has been observed for the Middle Jurassic deposits of the neighboring Tugnui Basin
27
28 377 (Arzhannikova et al., 2020) (see fig. 1B for location). The pre-existing cover sequence at the
29
30 378 Mongol-Okhotsk continental margin, containing zircons derived from the Angara-Vitim batholith,
31
32 379 was probably still largely preserved by the Early Cretaceous and participated to the clastic material
33
34 380 source. Although the contribution of recycled zircons to the deposits of the Gusinozersk Basin is
35
36 381 not significant: in the Murtoi Fm., zircons with the age of the Angara-Vitim batholith do not exceed
37
38 382 7%, and only single grains of this age are found in the overlying formations.

383 Single zircon grains with ages ranging from 330 to 400 Ma are found in samples from the
384 Lower Selenga Sfm. and Kholboldzhin Fm. There are no zircons of this age in the sample from
385 the Murtoi Fm. In the adjacent areas, volcanic rocks with such ages are not known (Wang et al.,
386 2022); therefore, the question of the provenance of these zircons remains open.

387 The youngest generations of zircons in the samples were found in the Murtoi Fm. and
388 Lower Selenga Sfm. These are composed of a very few single grains with ages ranging from ~116
389 to 145 Ma (Fig. 6 A, B). These ages correspond to the ages of single paleovolcanoes of

1
2 390 trachybasaltic and trachyandesite composition in the Khambin Ridge (127–124 Ma)
3
4 391 (Andryushchenko et al., 2010), large volcanoes of alkaline rhyolites (~140 Ma), including those
5
6 392 within the Monostoy Ridge (Yarmolyuk et al., 2000), as well as two stages of magmatic activity
7
8 393 that occurred in Western Transbaikalia at 143–135 Ma and 131–111 Ma (Vorontsov et al., 2016).
9
10 394 In their study, Vorontsov et al. (2016) pointed out that after 135 Ma, the emitted volume of
11
12 395 volcanic rocks sharply decreased and their composition changed from bimodal associations to
13
14 396 basaltoid ones. The predominance of mafic rocks among the Early Cretaceous volcanics (up to
15
16 397 90%) (Donskaya et al., 2013; Sheldrick et al., 2020) possibly explains the small number of zircons
17
18 398 of this age in the samples.
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23 399 Thus, our geochronological studies made it possible to clarify the onset time of the
24
25 400 formation of the Gusinozersk Basin. While it was previously considered as Middle Jurassic to
26
27 401 Early Cretaceous (Komarov, 1962; Martinson, 1961; Kolesnikov, 1964; Otchirov, 1964; Skoblo
28
29 402 et al., 2001 and others), our detrital zircon U-Pb age data from the basal Murtoi Fm. indicate that
30
31 403 the basin began to subside not earlier than ~136 million years ago (according to the age of the
32
33 404 youngest zircon in the sample). However, this age of ~136 Ma relies on a single grain and is
34
35 405 therefore statistically very weak. A more representative number of young zircons (3 grains) have
36
37 406 an age of 150–153 Ma (Supplementary Data, Tables S1). However, the age of ~136 Ma is in better
38
39 407 agreement with the biostratigraphic data. Based on freshwater mollusks, Kolesnikov (1980)
40
41 408 estimated the age of the Murtoi Fm as Berriasian – Valanginian (~145–132.9 Ma). Based on the
42
43 409 age of the ostracods, Scoblo et al. (2001) dated the Murtoi Fm. as Berriasian–Hauterivian (~145–
44
45 410 129.4 Ma). The spore-pollen assemblages associated with the overlying Selenga and Kholboldzhin
46
47 411 Fms. are characterized by Late Jurassic species, while the flora macro-remains in the same deposits
48
49 412 are Early Cretaceous (see for example the Old Zagustay samples in Jolivet et al., 2017). Jolivet et
50
51 413 al. (2017) also reported the occurrence of few Cretaceous spores and pollens from the Selenga
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53 414 Sfm., finally suggesting that the Selenga, Bainzorkhen and Kholboldshin Fms are of late Late
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55 415 Jurassic – Early Cretaceous age. Averianov et al. (2022) identified spore-pollen spectra from the
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1
2 416 Murtoi Fm., which correspond to those that were widespread across Siberia in the Lower
3
4 417 Cretaceous. For some species (*Foraminisporis asymmetricus* and *Rouuseisporites reticulatus*), the
5
6 418 lower stratigraphic limit corresponds to the middle of the lower Valanginian (Averianov et al.,
7
8 419 2022), which is in good agreement with the lower age limit of the formation at ~136 Ma obtained
9
10 420 in our work from the dating of the youngest zircon. This result suggests that the Jurassic spore-
11
12 421 pollen spectra found in the Selenga and Kholboldzhin Fms. (Jolivet et al., 2017) were indeed
13
14 422 recycled from the Jurassic sediments widespread in the region in the Lower Cretaceous. This
15
16 423 would explain the discrepancy between those Jurassic spore-pollen spectra and the Lower
17
18 424 Cretaceous age of the flora macro-remains found in the same formations. Indeed, while spores and
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20 425 pollens are small and resistant enough to be recycled from older sediment deposits (Stanley, 1966),
21
22 426 macro-remains, and especially soft parts such as leafs are impossible to recycled. Since the
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24 427 $^{40}\text{Ar}/^{39}\text{Ar}$ dating of the Khurai-Baiba dike complex, intruding the deposits of the Murtoi Fm.,
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26 428 showed an upper age limit of 130 ± 1 Ma for the basal formation, we suggest that the formation of
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28 429 the Gusinozersk Basin started at 136–130 Ma. These data are consistent with the biostratigraphic
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30 430 age of the Murtoi Fm. However, our new geochronological data narrows the age interval for the
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32 431 beginning of sedimentation in the Gusinozersk Basin.

38 432 **4.2. Taphonomy of the Mogoito locality series and paleoenvironmental application**

39 433 Based on the fossils found at the Mogoito locality, we can model the paleoenvironment at
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41 434 the time of the onset of sedimentation in the Gusinozersk Basin during deposition of the Murtoi
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43 435 Fm. It yielded the largest number of vertebrates remains from the Gusinozersk Basin. The
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45 436 Mogoito locality consists of a series of natural outcrops in shallow ravines and scours on the
46
47 437 western bank of Lake Gusinoe exposing sediments from the Murtoi Fm. The locality represents
48
49 438 an important source of information about the Early Cretaceous vertebrate fauna of Central Asia.
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51 439 The lower alluvial-proluvial part of the Murtoi section in Mogoito locality is made of large and
52
53 440 medium pebble conglomerates of varying rounding, gravelstone and sandstone containing rare
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55 441 fragmentary dinosaur fossils and remains of petrified wood. The upper alluvial part of the section

1
2 442 is composed of alluvial cross-bedded fine-to-coarse grain sandstone alternating with a thinner layer
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4 443 of shale and siltstone with remains of bivalve mollusks and vertebrates. The remains of fossil bones
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6 444 are randomly scattered in the sediments. There are no articulated skeletal elements here, and most
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8 445 of the bones are highly fragmented. Some bones were carried by water currents and rounded.

9
10
11 446 A major amount of fossils belongs to the sauropods *Tengrisaurus starkovi* (Averianov and
12
13 447 Skutschas, 2017; Averianov et al., 2021) belonging to the titanosaurs group. Remains of another
14
15 448 sauropod (Sauropoda indet.) are also present but yet under study (Averianov et al., 2022). Three
16
17 449 theropod groups have been identified from the Mogoito locality based on the isolated bones and
18
19 450 teeth: Ornithomimosauria, Therizinosauroida, and Dromaeosauridae (Averianov et al., 2003;
20
21 451 Averianov and Skutschas, 2009; Averianov et al., 2022). All available remains previously
22
23 452 identified as Ornithopoda indet. as well as a *Psittacosaurus* sp. (Averianov and Skutschas, 2009)
24
25 453 from Mogoito locality can be attributed to a representative of the basal ornithischian clade
26
27 454 Jeholosauridae indet. (Averianov et al., 2022). Remains of other diapsid reptiles such as lizards,
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29 455 pterosaurs, turtles *Kirgizemys dmitrievi* and choristoderes *Khurendukhosaurus* sp. (Skutschas and
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31 456 Vitenko, 2017) are also found. The fossil crocodyliforms, another reptile group found in more
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33 457 southern Late Mesozoic vertebrate faunas in Mongolia, have not been recorded so far from there.
34
35 458 This is most likely due to the cool climate, which is not suitable for crocodyliforms, although it is
36
37 459 impossible to exclude the possibility that they simply did not get into the paleontological record.
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39 460 Fish remains *Stichopterus* sp., Paleonisciformes indet., cf. *Irenichthys* sp. (Averianov and
40
41 461 Skutschas, 2009) are found in alluvial deposits. The discovery of the eutherian mammal
42
43 462 *Murtoilestes abramovi* (Averianov and Skutschas, 2001) in one of the Mogoito gullies is
44
45 463 noteworthy.

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47
48 464 The Mogoito locality is largely similar to the Khuren Dukh locality of Mongolia, sharing the
49
50 465 macrobaenid turtle *Kirgizemys* and the long-necked choristodere *Khurendukhosaurus* (Averianov
51
52 466 and Skutschas, 2000). However, abundant remains of *Psittacosaurus* at the Khuren Dukh locality
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54 467 (Kalandadze and Kurzanov, 1974) are not known in the Mogoito locality. Apparently, this

1
2 468 indicates an older age of the sediments in Mogoito, because when present, *Psittacosaurus* is the
3
4 469 most abundant dinosaur taxon in an assemblage (Averianov et al., 2022).
5

6 470 Dinosaurs cannot be used as good indicators of climate because some of them thrived and
7
8 471 even bred in the cool temperate climate above the Arctic Circle, such as in Kakanaut locality
9
10 472 (Chukotka, Russia). A CLAMP analysis of the Maastrichtian Kakanaut coastal paleoflora, using
11
12 473 the Physg3brcAZ and the WorldClim2 calibration data sets, yielded a mean annual temperature of
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14 474 ~12 °C, the warmest month having a mean temperature of ~21 °C, and the coldest month a mean
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16 475 temperature of ~5 °C (Zolina et al., 2020). However, the absence of crocodyliforms and the
17
18 476 presence of turtles and choristoderes in the Mogoito locality suggest a temperate climate, with an
19
20 477 annual mean temperature well above freezing level but below 14°C (Markwick, 1998; Mannion et
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22 478 al., 2015; Amiot, 2011). The sedimentation age of the Murtoi Fm. (136–130 Ma, this study)
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24 479 coincides with the global cooling Weissert Event, which took place at ~133 Ma (Cavalheiro et al.,
25
26 480 2021) during the earliest Cretaceous (Berriasian to Barremian) and can be characterized as
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28 481 something “in-between” a hothouse and an icehouse (Fig. 8). The average global temperature was
29
30 482 about 17°C (Scotese et al., 2021).
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36 483 All palynological samples from the Mogoito locality revealed only rare palynomorphs
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38 484 including spores and pollen of terrestrial plants and freshwater microphytoplankton. The low
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40 485 counts in palynomorphs could be probably attributed to a taphonomic bias related to the coarse-
41
42 486 grained character of the deposits less favorable to the accumulation of light-weighted organic
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44 487 material. Terrestrial palynomorphs are represented by spores of cyatheaceous/dipteridaceous,
45
46 488 osmundaceous and schizaeaceous ferns, liverworts and lycopods, ginkgoalean pollen grains and
47
48 489 saccate pollen of conifers. Stratigraphically important taxa include *Cicatricosisporites* sp.,
49
50 490 *Foraminisporis asymmetricus* and *Rouseisporites reticulatus*, which were widespread across
51
52 491 Siberia in the Lower Cretaceous (Averianov et al., 2022).
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56
57 492 Taking into account the data on ostracods and malacofauna, it can be assumed that in the
58
59 493 Murtoi time there were no large deep lakes in the Gusinozersk Basin. Water bodies rather
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1
2 494 consisted in a series of small open lakes and oxbow lakes. The climate was cooler than in
3
4 495 subsequent ages although absolute temperature ranges are difficult to estimate.
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6 496 The overlying Ubukun Fm. is represented by lacustrine sediments. All fossil fauna found
7
8 497 here is limnophilic. The morphological features of ostracods in the lower part of the formation
9
10 498 indicate a depth of the paleolake of 50-100 m. The main representatives of ostracods here are
11
12 499 *Mongolianella subexsortis*, *M. rocodi*, *M. substriata*, *Limnocypridea grammi* (Skoblo et al. 2001).
13
14
15 500 In the upper part of the formation, the faunal complex changes. Forms characteristic of small
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17 501 marshy lakes appear. The complex of bivalves given by (Kolesnikov, 1977) contains forms
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19 502 characteristic of the entire Gusinoozersk Series. Vertebrate remains have not been found here, with
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21 503 the exception of one aquatic macrobaenid turtle *Kirgizemys* (similar to those found in the Murtoi
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23 504 Fm.), which, most likely, comes from the Ubukun Fm. (Danilov et al., 2006).
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26
27 505 The Selenga and Kholboldzhin Fms. are represented by alluvial and lacustrine-alluvial
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29 506 deposits. The lakes were periodically swamped, and the lacustrine-swampy sediments were later
30
31 507 repeatedly eroded by the river. In the Selenga Fm. several marker horizons contain (from bottom
32
33 508 to top) *Limnocypridea defense*, *Darwinula murtoensis*, *Cypridea selenginensis*, which were living
34
35 509 in large open lakes (Skoblo et al., 2001). Marking horizons containing *Cypridea zagustaica* and
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37 510 Ferganoconchidae correspond to the facies of shallow stagnant bodies (Skoblo et al. 2001).
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39 511 According to (Vakhrameev, 1964, 1982), plant remains, such as *Cyparissidium gracile*,
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41 512 *Pterophyllum sensovianum*, *Coniopteris (Birisia) onychioides*, *Sphenopteris (Ruffordia)*
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43 513 *goeppertii*, *Onychiopsis elongate*, *Scleropteris dahurica*, belong to typical Early Cretaceous forms.
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46
47 514 A large number of fossils remains of flora and fauna thus make it possible to reconstruct the
48
49 515 paleoenvironmental evolution of the basin. The onset of formation of the Gusinoozersk Basin
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51 516 coincided with the global cooling Weissert Event. During that period the temperate climate
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53 517 prevailing in Transbaikalia was favorable to the existence and reproduction of dinosaur, turtles
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55 518 and choristoderes, but not suitable for crocodiles. Following the small-scale open-water lakes and
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57 519 marshes of the Murtoi Fm., deep lakes (or a single, large lake) formed during the deposition time
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1
2 520 of the Ubukun Fm. This is supported both by the sediment facies and the rich ostracod fauna. Later,
3
4 521 in the early Selenga Sub-fm. time, the lakes periodically decreased in size, and in the late Selenga
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6 522 and Kholboldzhin times, there were again a series of small swampy lakes.
7

8 523 **4.3. Tectonic evolution of the Gusinozersk Basin**

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11 524 The vast majority of detrital zircon ages in the sample of the Murtoi Fm. correspond to the
12
13 525 age of the volcanic rocks of the Khambin Ridge bordering the basin to the West. There are almost
14
15 526 no zircons with ages corresponding to the volcanic rocks of the Monostoy Ridge in the sample.
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17 527 These two results suggest that most of the topographic relief was mainly localized to the West,
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19 528 further suggesting that the subsidence of the Gusinozersk Basin at the initial stage was mainly
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21 529 controlled by the Khambin Fault. The basin thus initially developed as a west-tilted (actual
22
23 530 reference frame) semi-graben (Fig. 9A). By this time, the predominant deposits were proximal
24
25 531 deposits from braided rivers draining the Khambin Ridge. In the overlying formations, represented
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27 532 by fine-grained material, there is only minor amount of zircons with ages matching the Khambin
28
29 533 volcanic rocks (see Fig. 6B, C). However, these samples contain a zircon age population consistent
30
31 534 with the age range of the Early Jurassic bimodal association, identified within the Monostoy Ridge
32
33 535 to the East (Yarmolyuk et al., 2000) (see Fig. 2). The absence of “monostoy” zircons in the basal
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35 536 Murtoi Fm. and their presence in the Lower Selenga Sfm. and Kholboldzhin Fm. indicate the
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37 537 formation of a positive relief to the East. This suggests an activation of the Monostoy normal fault
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39 538 later than the accumulation time of the Murtoi Fm. (Fig. 9B). The beginning of the subsidence of
40
41 539 the eastern side of the basin was accompanied by simultaneous erosion of the Monostoy Ridge.
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43 540 This is also supported by the deposition of the coarse-grained “Monostoy” facies sediments,
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45 541 starting from the Lower Selenga Sfm. and higher along the section, which facially replaced coal-
46
47 542 bearing deposits (Skoblo et al., 2001) (see fig. 3 and 9B). Since the age of the Lower Selenga Sfm.,
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49 543 according to the youngest zircon in the sample, is younger than ~116 Ma, it can be argued that the
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51 544 Monostoy Fault began to control the subsidence of the basin not earlier than this time. As in the
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53 545 case of the Murtoi Fm., the age is estimated from a single grain and should be taken with caution.
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2 546 The next young zircon has an age of ~171 Ma (Supplementary Data, Tables S2), which is
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4 547 obviously older than the age of the underlying Murtoi Fm. The absence of a sufficient amount of
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6 548 young zircons, corresponding to the age of sedimentation of the Selenga Fm., is possibly related
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8 549 to the mafic composition of volcanism characteristic of this time (Donskaya et al., 2013; Vorontsov
9
10 550 et al., 2016; Sheldrick et al., 2020). Thus, we rely on the only obtained date of ~116 Ma to
11
12 551 characterize the age of the Lower Selenga Sfm., but at the same time we assume that the beginning
13
14 552 of its deposition may be older, but not older than ~130 Ma. Since the thickness of the sediments
15
16 553 in the basin is not constant (there is a trend towards an increase in thickness from the western to
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18 554 the eastern side (Bulnaev, 2006)), the Monostoy Fault most probably played a major role in the
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20 555 second stage of the development of the basin, which started with the beginning of the accumulation
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22 556 of the Selenga Fm. (Fig. 9).

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27 557 The Khambin and Monostoy faults are trending obliquely to the direction of the Buteel
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29 558 metamorphic core complex, and their activation is not directly related to its tectonic exposure.
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31 559 However, the coincidence in time between the onset of active subsidence in the Gusinozersk
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33 560 Basin and the exhumation of the Buteel core complex suggest that they interacted structurally
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35 561 during a single process of crustal extension. The Khambin Fault participates to the Dzhida-Vitim
36
37 562 structural suture (see fig. 1B for location), which is the boundary between the regions of Late
38
39 563 Proterozoic Baikalian and Early Paleozoic Caledonian folding (Luchitsky, 1975). The Mesozoic
40
41 564 reactivation of the Dzhida-Vitim structure has been evidenced along its entire length. It controlled
42
43 565 the development of the Dzhida-Vitim depression zone, represented by a chain of Mesozoic
44
45 566 depressions, which include the Gusinozersk Basin. Cretaceous reactivation has also been
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47 567 recorded along the Primorsky structural suture in the neighbouring Baikal region (see fig. 1B for
48
49 568 location). The apatite fission track data from the Primorsky Ridge and the Olkhon block show
50
51 569 rapid exhumation at 140–120 Ma along the Primorsky suture (Van der Beek et al., 1996; Jolivet
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53 570 et al., 2009). Thus, during the Cretaceous extension, large inherited structures were activated. The
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55 571 basins of Transbaikalia were formed both in conjunction with the exhumation of metamorphic

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2 572 core complexes and mainly located along reactivated structural sutures. While middle to lower
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4 573 crust was exhumed to the surface within the metamorphic core complexes, the probably
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6 574 Cretaceous basins developed along listric faults rooting in the ductile decollement zone at depth
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8
9 575 (Wernicke, 1981; Donskaya et al., 2008; Mazukabzov et al., 2011).

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11 576 The basal Murtoi Fm. is composed mainly of poorly sorted conglomerates, which we
12
13 577 interpret as representing rapid erosion linked to the active subsidence of the depression at the initial
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15 578 stage and the formation of alluvial fans at the foot of the Khambin Ridge (see fig. 9A). The remote
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17 579 provinces located to the south of the basin also took a small part in the sedimentation during that
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19 580 time – the rivers started transporting clastic material from the Buteel metamorphic core complex.
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21 581 A modern analogue of such rivers could be the Selenga River, whose catchment includes this
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23 582 region. The Selenga River flows to the northeast, passing near the Gusinozersk Basin through the
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25 583 Monostoy Ridge, and flows into Lake Baikal (see fig. 1B). Among the detrital zircons extracted
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27 584 from modern deposits of the Selenga River Delta (Ivanov et al., 2016), some display U-Pb ages
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29 585 corresponding to the age of syenites of the Burgutuy massif of the Buteel metamorphic core
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31 586 complex. We thus assume that during the accumulation of the Gusinozersk Basin such a river
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33 587 flowed through the basin towards the Siberian Craton, unloading sediments transported from the
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35 588 southern provinces within the basin. An increase in the contribution of the southern sources up the
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37 589 section indicates either that they have become more eroded or that local sources have decreased.
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43 590 Fine-grained sediments of the Selenga and Kholboldzhin Fms. (sandstones, siltstones,
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45 591 mudstones with interlayers of coals) indicate that, starting from the middle Aptian (considering
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47 592 that the ~116 Ma zircon age corresponds to the lower limit of sedimentation), Western
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49 593 Transbaikalia evolved in a relatively calm tectonic regime, characterized by the slow subsidence
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51 594 in the various basins and the continuing denudation of not yet completely eroded ridges. At that
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53 595 time, the Monostoy Fault still played the main role in the subsidence of the depression. This is
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55 596 confirmed by the deposition of the "Monostoy" conglomerates at the foot of the Monostoy Ridge,
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57 597 laterally replacing the fine-grained sediments of the Selenga and Kholboldzhin fms, and by the
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1
2 598 occurrence of zircons derived from volcanic rocks located in the Monostoy Ridge. The
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4 599 "Monostoy" facies corresponds to the proximal parts of the alluvial fans deposited by the rivers
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6 600 that were draining the Monostoy Ridge. In the central part of the basin, distal alluvial plain
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8 601 sediment facies accumulated in fluvial and lacustrine-swamp environments (see fig. 9B). The
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10 602 decrease in the subsidence rate of the depression and smoothing of the topography led to the
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12 603 overfilling of the depression with sediments, swamping and peat formation, which gave rise to the
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14 604 formation of coal.
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18 605 Thus, by the end of the Early Cretaceous, the topography finally flattened out and the
19
20 606 Gusinozersk Basin ceases to be an area of sedimentation. However, it seems that the process of
21
22 607 collapse of the Mongol-Okhotsk orogen does not end there, and the extension is shifted closer to
23
24 608 the boundary of the Siberian Craton to the area of the Baikal rift system. For example, Van der
25
26 609 Beek et al. (1996) and Jolivet et al. (2009) based on apatite fission track data showed the
27
28 610 reactivation of the Primorsky and Barguzin faults of the Baikal rift system (see Fig. 1 for location)
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30 611 in the Late Cretaceous and interpreted it as a continuation of postorogenic extension in
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32 612 Transbaikalia.
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37 38 614 **5. Conclusions**

39
40 615 Geochronological dating of sedimentary and igneous rocks of the Gusinozersk Basin
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42 616 made it possible to clarify the age of paleogeographic events associated with the collapse of the
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44 617 Mongol-Okhotsk orogen in Western Transbaikalia. U/Pb (LA-ICP-MS) dating of detrital zircons
45
46 618 from sedimentary deposits and $^{40}\text{Ar}/^{39}\text{Ar}$ dating of intruding volcanic rocks showed that the
47
48 619 formation of the Cretaceous basins of Transbaikalia began around 136–130 Ma. It is related to the
49
50 620 main episode of extension associated with the exhumation of metamorphic core complexes.
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54 621 The lowest coarse-clastic Murtoi Fm. characterizes the rapid subsidence of the basin and
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56 622 the predominance of proximal sediment sources. The provinces located south of the Gusinozersk
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2 623 Basin also made a contribution to sedimentation indicating the rise of a positive topography
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4 624 associated with the exhumation of the metamorphic core complexes.
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6 625 From the middle of the Aptian, Western Transbaikalia developed in a relatively calm
7
8 626 tectonic regime, as evidenced by fine-grained deposits of the Selenga Sfm. and Kholboldzhin Fm.
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10
11 627 Within the general pattern of a significant smoothing of the topography, the exposed metamorphic
12
13 628 cores complexes continued to be a source of sediments for the basins of Transbaikalia.
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15 629 The subsidence of the Gusinozersk Basin was controlled by two side faults: at an early
16
17 630 stage, by the Khambin Fault, and at a later stage, by the Monostoy Fault. The Khambin Fault is an
18
19 631 inherited Paleozoic structure reactivated during Cretaceous extension. The basins of Transbaikalia
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21 632 were formed both in conjunction with the exhumation of metamorphic cores complexes and
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23 633 reactivated structural sutures.
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27 634 New data on dinosaur fauna and palynology, together with the dating of host deposits,
28
29 635 made it possible to correct the age of faunal assemblages in Western Transbaikalia, which is very
30
31 636 important for biostratigraphic correlations in various regions of Central Asia. The onset of
32
33 637 formation of the Gusinozersk Basin coincided with the global cooling Weissert Event. During
34
35 638 that period the temperate climate prevailing in Transbaikalia was favorable to the existence and
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37 639 reproduction of dinosaur, turtles and choristoderes, but not suitable for crocodiles.
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41 640

42 43 641 **Acknowledgments**

44
45 642 The study was conducted in the frame of the grant of the Ministry of Science and High
46
47 643 Education of the Russian Federation No. 075-15-2022-1100. Detrital zircons were extracted from
48
49 644 the bulk sample and prepared for U–Pb analysis at the Centre for Geodynamics and
50
51 645 Geochronology of the Institute of the Earth’s Crust SB RAS (Irkutsk, Russia). U–Pb isotope
52
53 646 analysis of zircons was made at the “Analytical center of mineralogical, geochemical and isotope
54
55 647 studies” at the Geological Institute, SB RAS (Ulan-Ude, Russia). After reduction of data in Glitter
56
57 648 (Griffin, 2008), all calculations were conducted using Dezirteer program, specially designed for
58
59
60

1
2 649 the analysis of U-Pb detrital zircon data (Powerman et al., 2021). The latter can be downloaded
3
4 650 for free at <http://dezirteer.com/> or used online at <https://dezirteer.crust.irk.ru/>. We thank three
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7
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9 652 manuscript.

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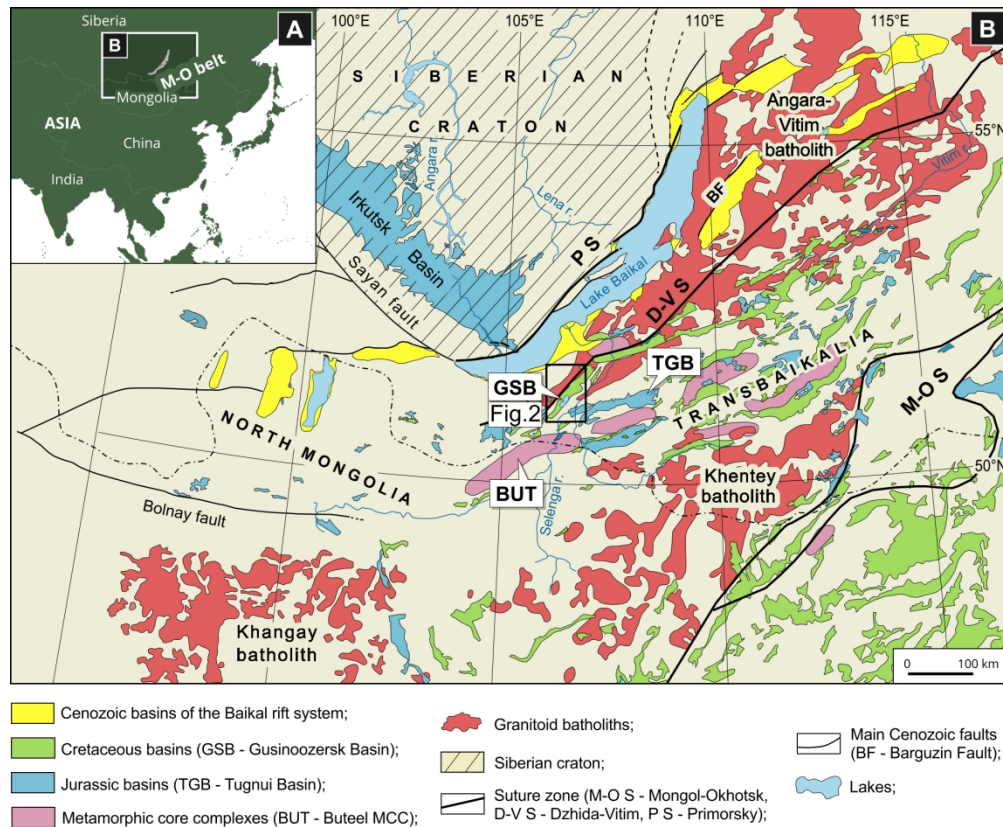


Fig. 1. A - Location of the Mongol-Okhotsk orogenic belt (M-O belt) on the map of Asia; B - Geological setting of Transbaikalia and adjacent areas (Qi and Wang, 2008; Jolivet et al., 2013; Yarmolyuk et al., 2016): 1 - Siberian craton, 2 - Lakes, 3 - Jurassic basins (TGB - Tugnu Basin), 4 - Cretaceous basins (GSB - Gusinozersk Basin), 5 - Cenozoic basins of the Baikal rift system, 6 - Metamorphic core complexes (BUT - Buteel MCC), 7 - Granitoid batholiths, 8 - Suture zone: M-O S - Mongol-Okhotsk, D-V S - Dzhida-Vitim, P S - Primorsky, 9 - Main Cenozoic faults: BF - Barguzin Fault.

175x144mm (300 x 300 DPI)

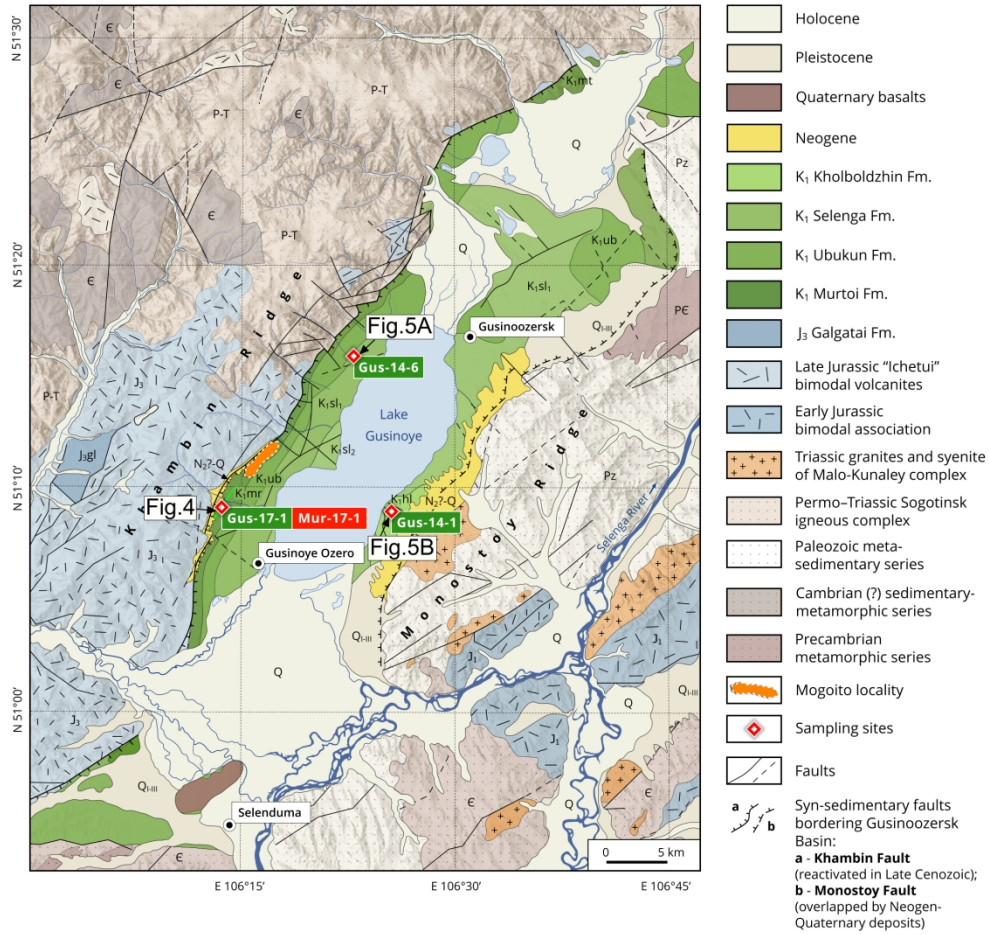


Fig. 2. Simplified geological map of the Gusinozersk Basin and surrounding area showing the outcrops of Mesozoic deposits based on the Russian geological map (Komarov, 1962) with modifications and additions after Jolivet et al. (2017) with the refinement of some rock ages after Yarmolyuk et al. (2000); Andryushchenko et al. (2010), Platov et al. (2013) and Bulnaev (2006). Here and below, the sample numbers are indicated in the rectangles. Samples dated ⁴⁰Ar/³⁹Ar (volcanites) are marked in red, and U-Pb (detrital zircons) are marked in green.

180x171mm (300 x 300 DPI)

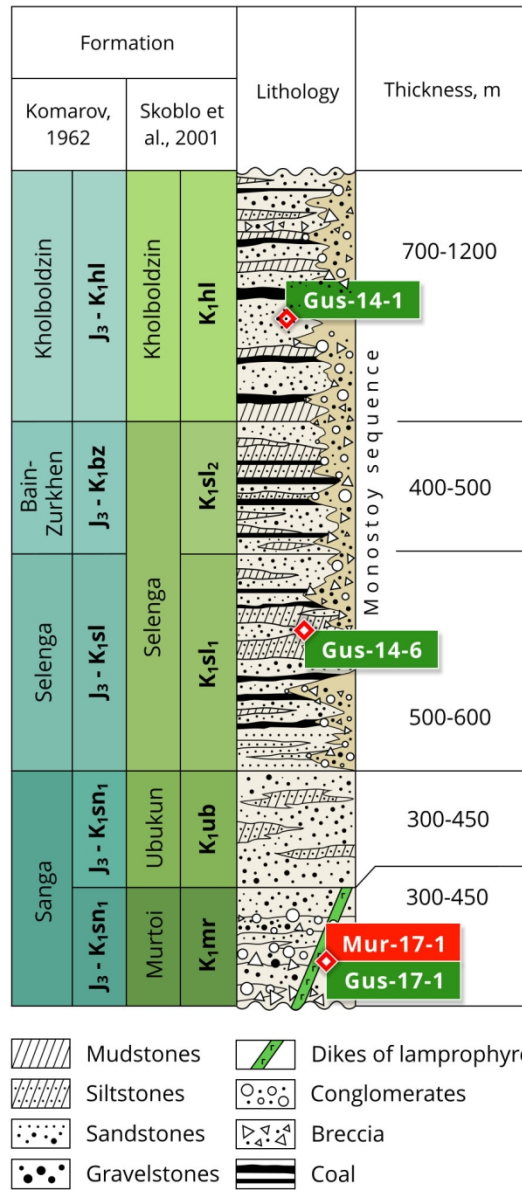


Fig. 3 Stratigraphy of the Early Cretaceous deposits of the Gusinozersk Basin after Komarov (1962), modified after Skoblo et al. (2001). Red square indicates samples position (schematically, without reference to depth and upper/lower parts of fms.).

77x172mm (300 x 300 DPI)

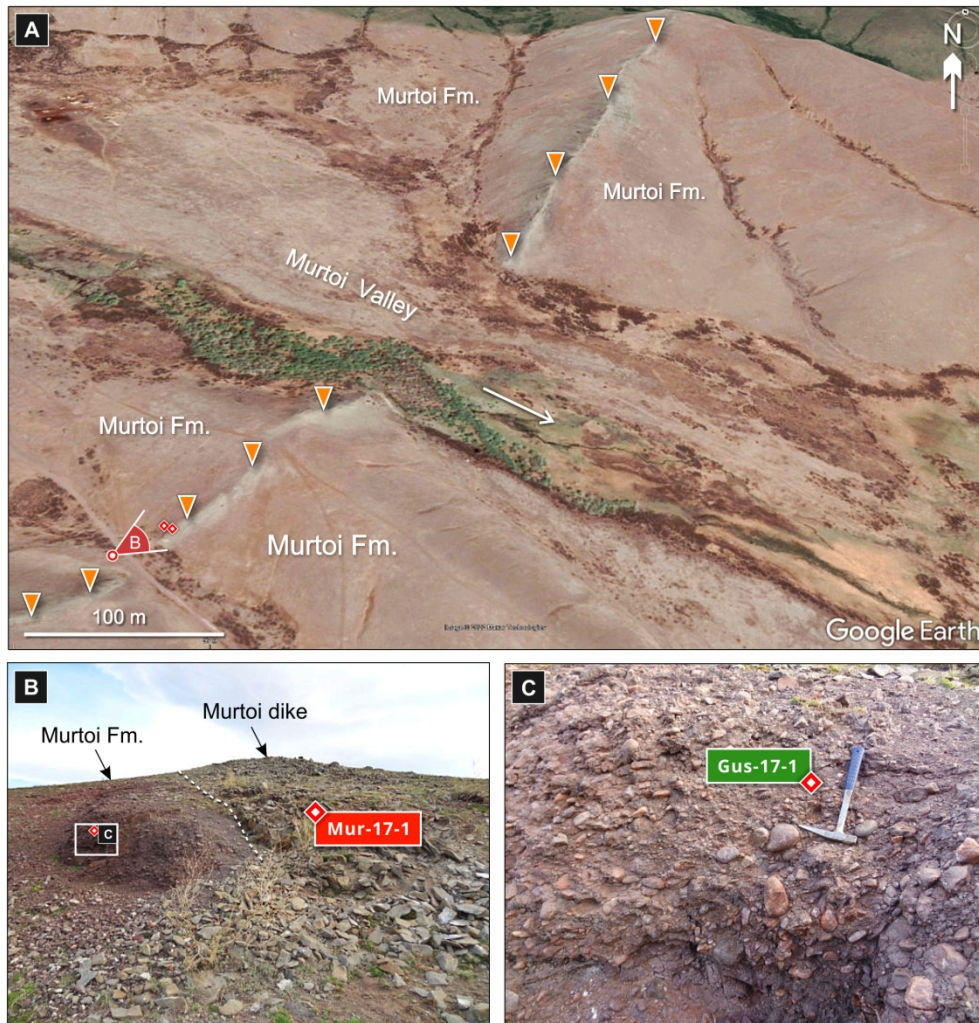


Fig. 4. (A) Google Earth satellite image of the Murtoi Fm. intruded by the Murtoi dike (indicated by orange triangles). Field view (B) and zoom (C) of the sampling site.

180x186mm (300 x 300 DPI)

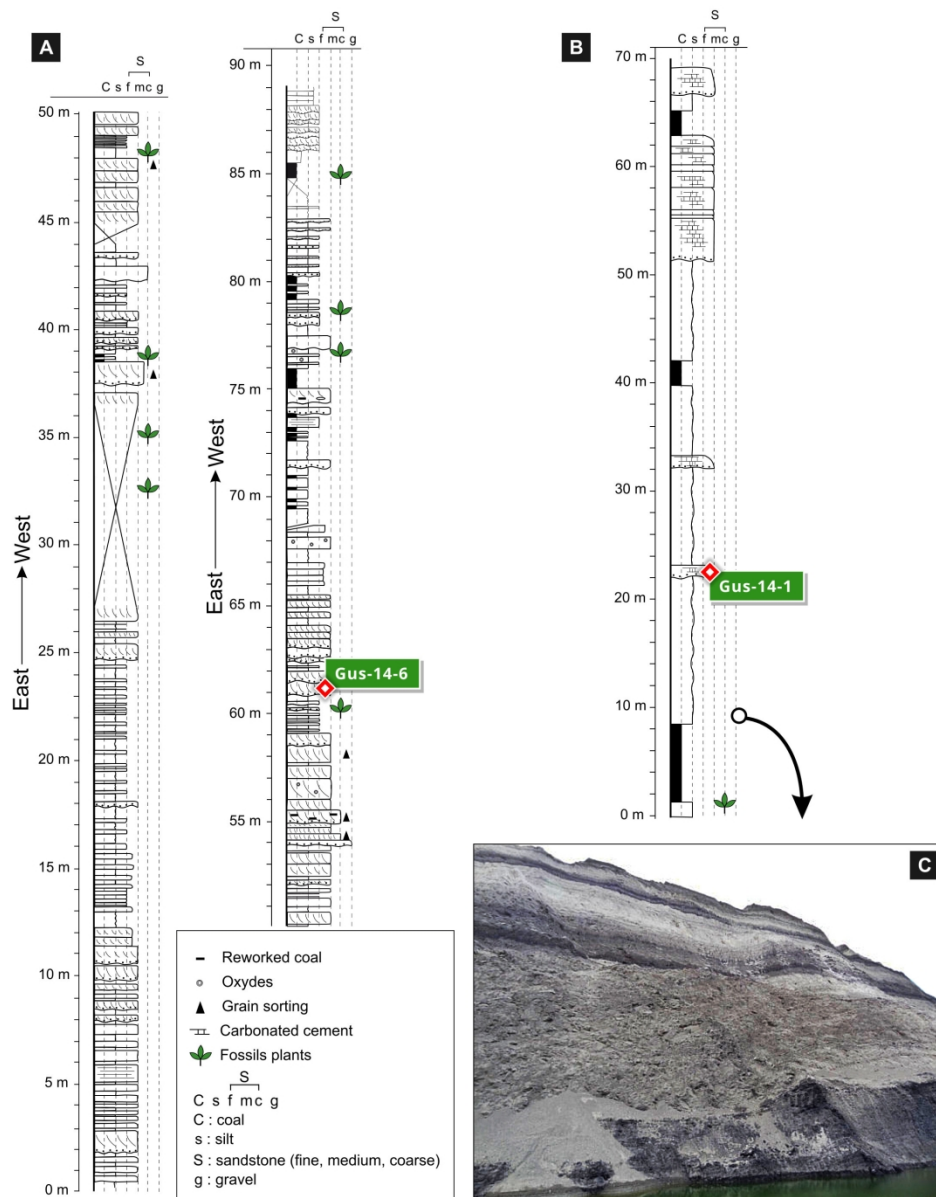


Fig. 5. Sections of sedimentary deposits of the Selenga Fm. (A) and Kholboldzhin Fm. (B) at sampling sites for U-Pb dating of detrital zircons (modified after Jolivet et al. (2017)). Red squares indicate sampling locations within the section. C - Field view of the Kholboldzhin Fm. section.

187x237mm (300 x 300 DPI)

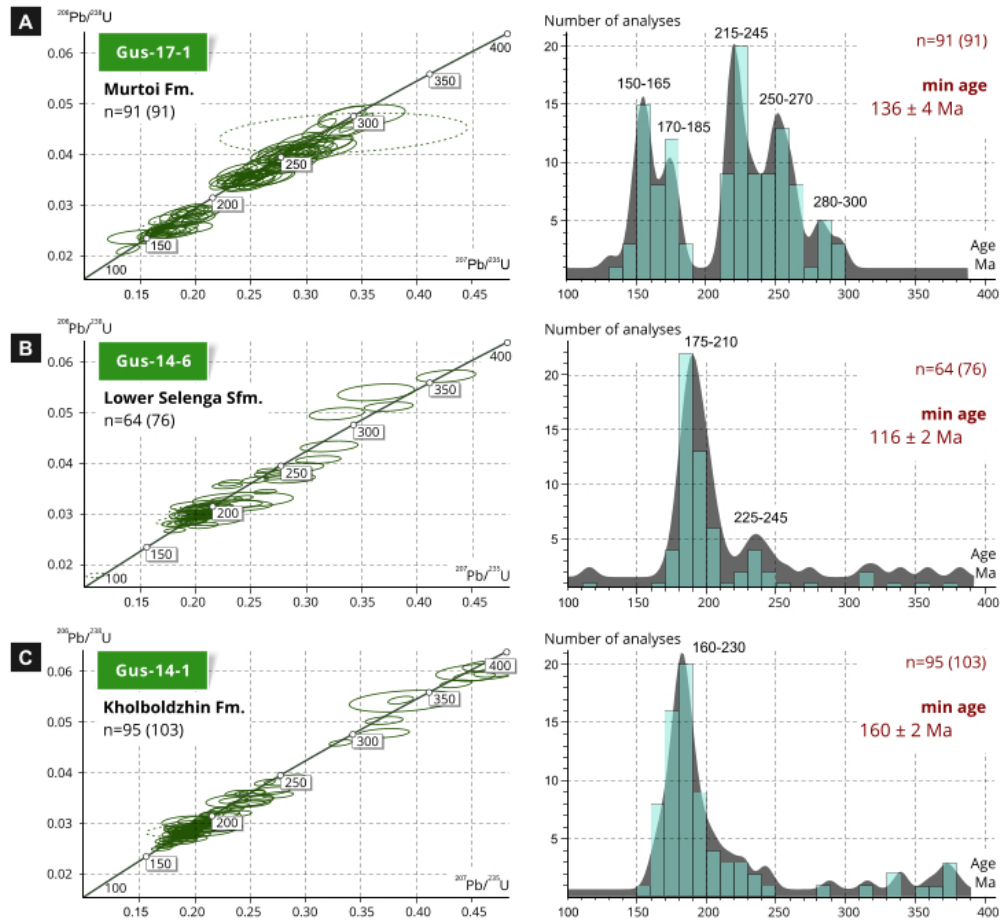


Fig. 6. U-Pb concordia diagrams and histograms coupled with kernel density estimates (grey area) for zircons from A – Murtoi Fm., B – Lower Selenga Sfm., C – Kholboldzhin Fm. n – number of grains younger than 400 Ma, in brackets - the number of all concordant ages.

192x177mm (96 x 96 DPI)

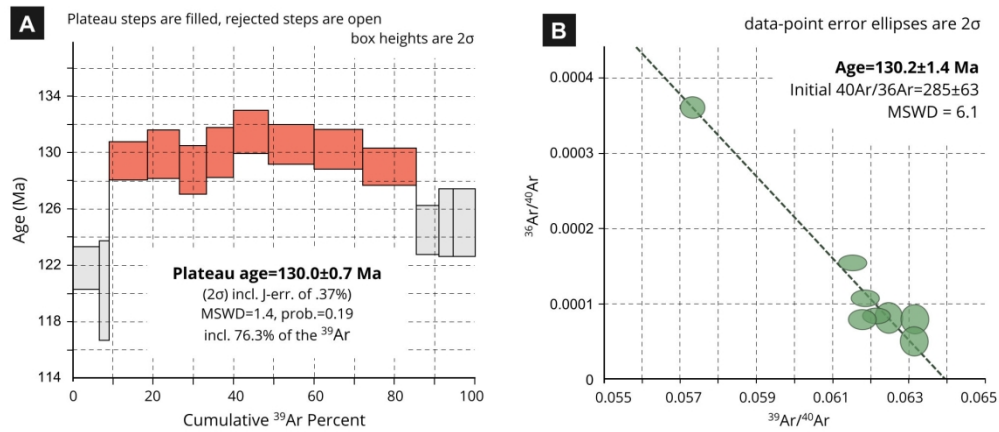


Fig. 7. Stepwise heating (A) and inverse isochrone (B) plots for volcanic sample Mur-17-1 from the Murtoi dike.

172x75mm (300 x 300 DPI)

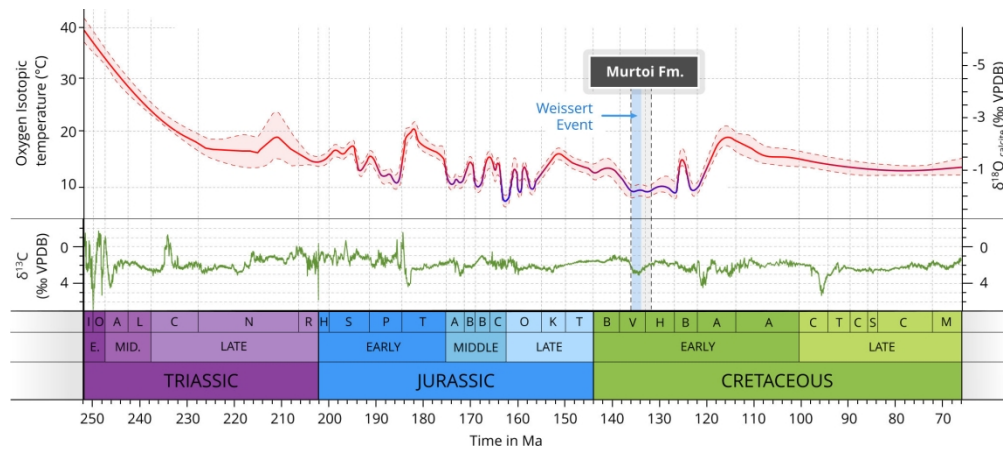
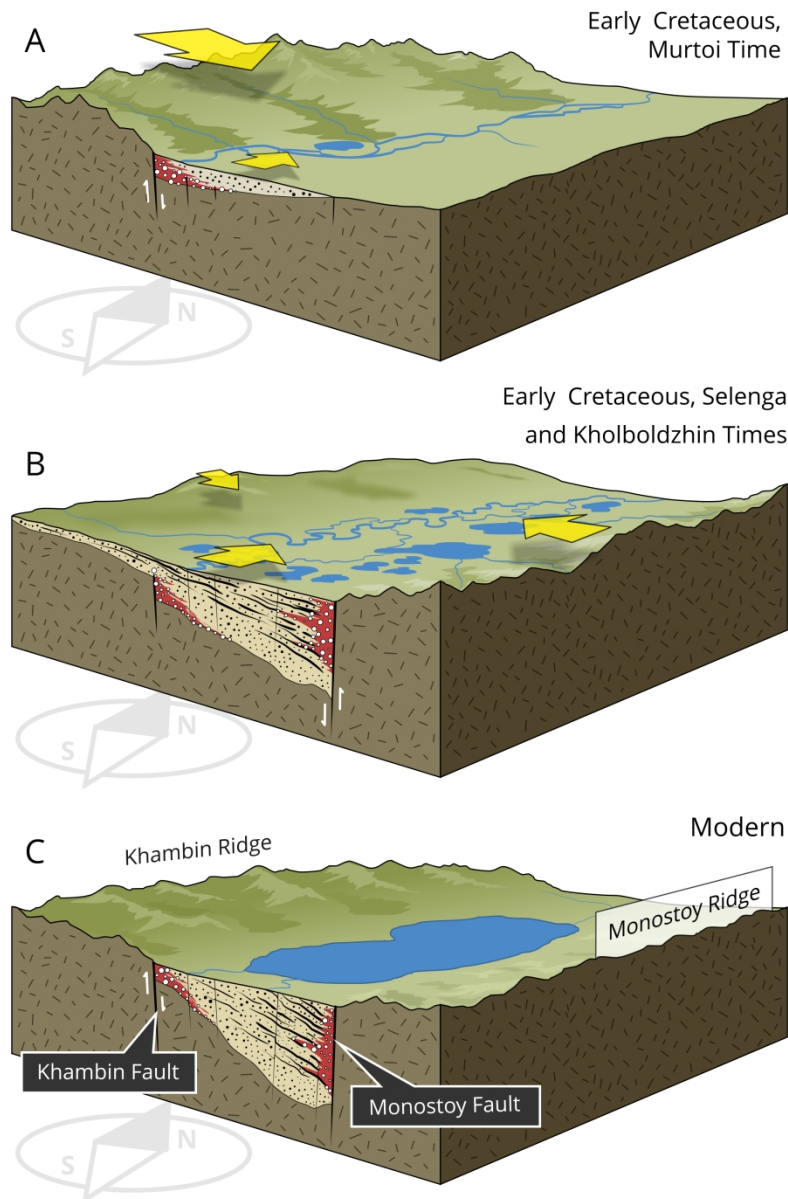


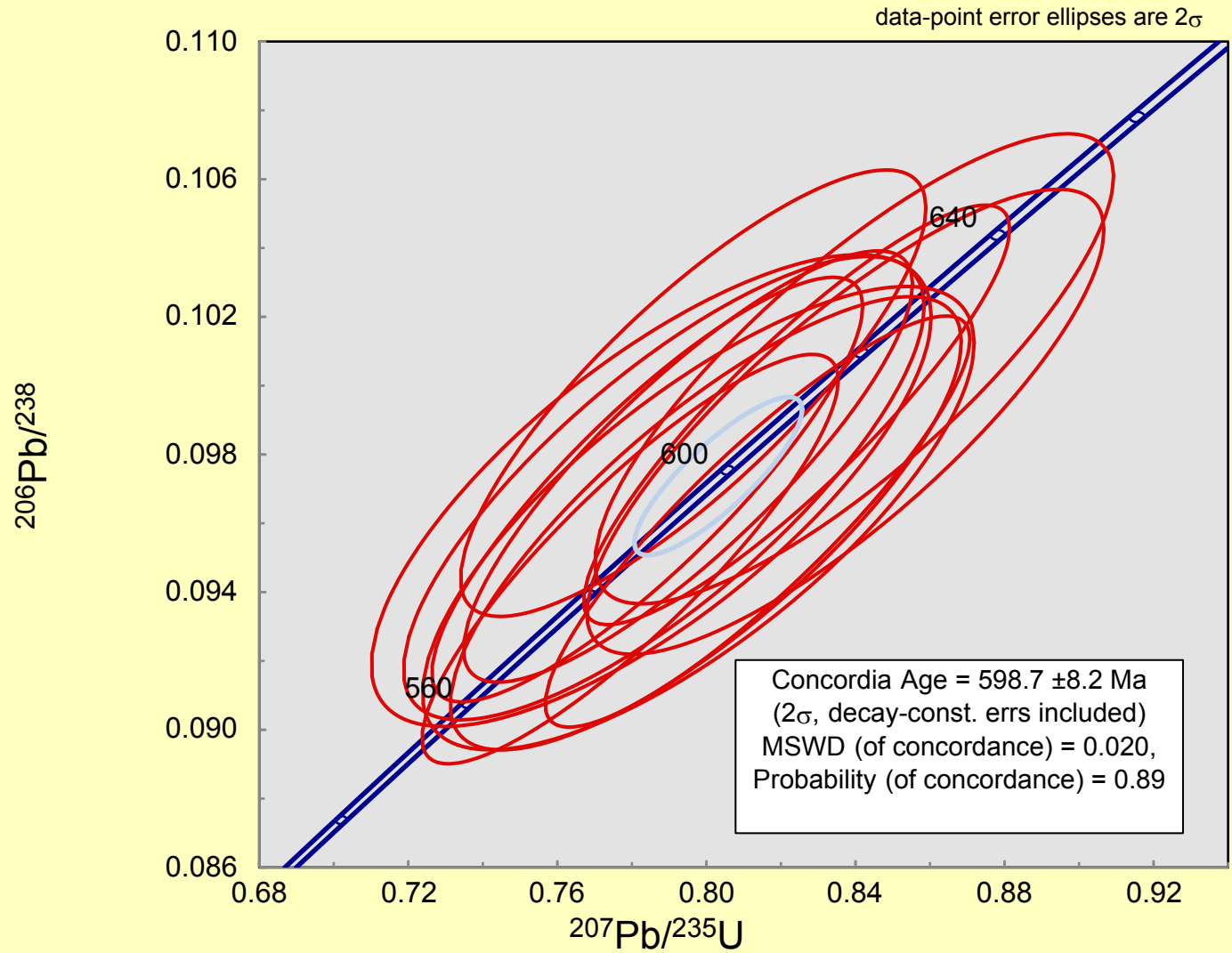
Fig. 8. A Mesozoic Oxygen and Carbon isotope records with the addition of the time of deposition of the Murtoi Fm. and the Weissert Event. For Oxygen isotopic red-blue bold line represents Locfit regression and dashed lines show $\pm 95\%$ confidence interval (Grossman et al., 2020). Green line represents variation in $\delta^{13}\text{C}_{\text{carb}}$ through the Mesozoic (Cramer et al., 2020).

173x75mm (300 x 300 DPI)

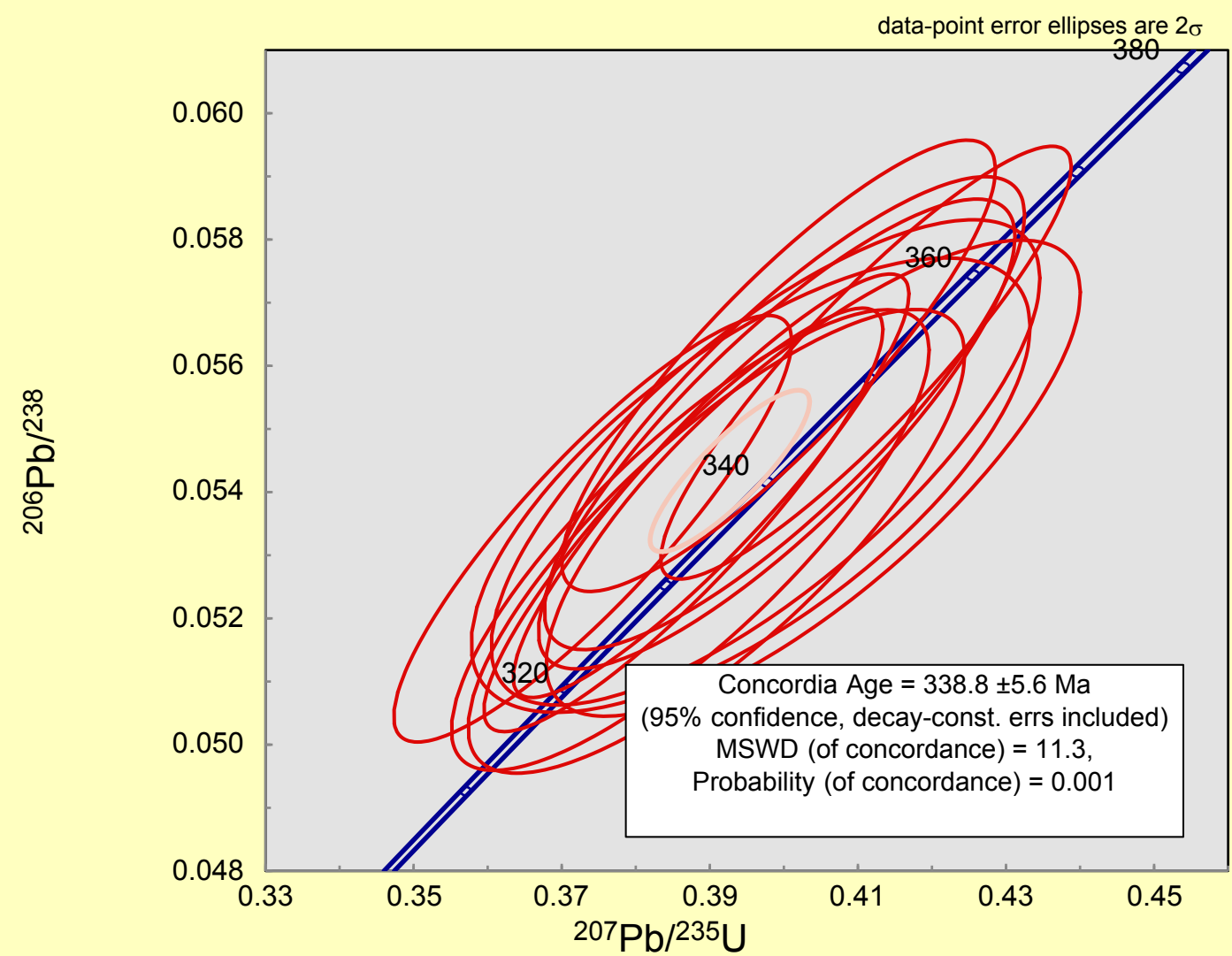


45 Fig. 9. Paleogeographical models of the Gusinozersk Basin for the Murtoi (A), Selenga and Kholboldzhin (B)
46 and modern (C) time showing tectonic control of the basin subsidence and evolution of provenance of the
47 deposits (for Lower Cretaceous stages). Yellow arrows show the direction of sediment transport. The size of
48 the arrows indicates the contribution of sediments from different provinces.

49 90x135mm (600 x 600 DPI)



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#	Изотопные отношения							
	$\frac{\text{Th}}{\text{U}}$	1 σ (abs)	$\frac{^{207}\text{Pb}}{^{206}\text{Pb}}$	1 σ (abs)	$\frac{^{208}\text{Pb}}{^{232}\text{Th}}$	1 σ (abs)	$\frac{^{207}\text{Pb}}{^{235}\text{U}}$	1 σ (abs)
GUS-17-1	number of sample		91 zircons					
PRB57	1.04	0.0395	0.0486	0.0024	0.0067	0.0002	0.1428	0.0068
PRB68	1.36	0.0526	0.0512	0.0029	0.0075	0.0002	0.1664	0.0091
PRB58	0.94	0.0362	0.0463	0.0056	0.0080	0.0004	0.1521	0.0181
PRB107	1.75	0.0715	0.0507	0.0030	0.0072	0.0003	0.1679	0.0096
PRB86	2.36	0.0932	0.0502	0.0035	0.0075	0.0003	0.1685	0.0115
PRB83	1.70	0.0666	0.0520	0.0029	0.0075	0.0002	0.1753	0.0094
PRB79	1.17	0.0458	0.0484	0.0022	0.0078	0.0002	0.1643	0.0070
PRB34	0.86	0.0324	0.0532	0.0036	0.0077	0.0003	0.1811	0.0119
PRB84	1.24	0.0492	0.0533	0.0046	0.0081	0.0003	0.1819	0.0153
PRB29	1.24	0.0465	0.0512	0.0022	0.0072	0.0002	0.1763	0.0071
PRB41	0.92	0.0347	0.0514	0.0036	0.0067	0.0003	0.1770	0.0118
PRB18	1.28	0.0482	0.0491	0.0023	0.0072	0.0002	0.1695	0.0072
PRB48	2.16	0.0813	0.0488	0.0020	0.0073	0.0002	0.1695	0.0063
PRB7	1.26	0.0474	0.0518	0.0029	0.0082	0.0002	0.1811	0.0094
PRB14	1.20	0.0451	0.0546	0.0028	0.0073	0.0002	0.1919	0.0090
PRB101	1.86	0.0750	0.0481	0.0019	0.0076	0.0002	0.1696	0.0063
PRB33	1.03	0.0386	0.0494	0.0017	0.0074	0.0002	0.1744	0.0054
PRB9	0.90	0.0342	0.0542	0.0052	0.0086	0.0004	0.1913	0.0179
PRB27	1.10	0.0414	0.0461	0.0023	0.0074	0.0002	0.1635	0.0074
PRB98	1.00	0.0403	0.0512	0.0028	0.0080	0.0003	0.1910	0.0102
PRB15	1.31	0.0493	0.0470	0.0027	0.0082	0.0002	0.1759	0.0096
PRB97	1.28	0.0513	0.0528	0.0030	0.0086	0.0003	0.1982	0.0107
PRB62	1.16	0.0443	0.0544	0.0028	0.0083	0.0003	0.2058	0.0100
PRB65	0.99	0.0380	0.0534	0.0025	0.0089	0.0003	0.2051	0.0090
PRB67	0.87	0.0336	0.0508	0.0029	0.0091	0.0003	0.1953	0.0106
PRB75	0.65	0.0254	0.0474	0.0023	0.0087	0.0003	0.1836	0.0083
PRB21	0.82	0.0309	0.0534	0.0028	0.0090	0.0003	0.2092	0.0104
PRB47	1.78	0.0673	0.0490	0.0020	0.0083	0.0002	0.1931	0.0073
PRB78	1.07	0.0416	0.0515	0.0021	0.0085	0.0002	0.2035	0.0077
PRB1a	1.52	0.0617	0.0479	0.0021	0.0086	0.0003	0.1894	0.0081
PRB64	0.70	0.0270	0.0510	0.0028	0.0086	0.0003	0.2023	0.0106
PRB82	1.23	0.0484	0.0494	0.0027	0.0086	0.0003	0.1968	0.0103
PRB42	0.95	0.0360	0.0523	0.0027	0.0096	0.0003	0.2459	0.0119
PRB59	1.73	0.0657	0.0518	0.0021	0.0108	0.0003	0.2454	0.0093
PRB63	1.16	0.0445	0.0544	0.0023	0.0110	0.0003	0.2579	0.0105
PRB108	1.19	0.0486	0.0485	0.0022	0.0107	0.0004	0.2314	0.0102
PRB80	1.93	0.0754	0.0534	0.0025	0.0109	0.0003	0.2557	0.0114
PRB56	1.68	0.0639	0.0500	0.0021	0.0108	0.0003	0.2400	0.0093
PRB51	2.11	0.0795	0.0490	0.0020	0.0102	0.0003	0.2356	0.0090
PRB92	1.66	0.0661	0.0508	0.0025	0.0106	0.0003	0.2459	0.0114
PRB11	1.42	0.0538	0.0495	0.0034	0.0112	0.0003	0.2396	0.0158
PRB22	0.77	0.0290	0.0544	0.0024	0.0106	0.0003	0.2641	0.0106
PRB77	0.36	0.0140	0.0496	0.0020	0.0108	0.0003	0.2408	0.0090
PRB43	1.46	0.0551	0.0517	0.0022	0.0104	0.0003	0.2516	0.0097
PRB66	1.47	0.0566	0.0523	0.0021	0.0104	0.0003	0.2546	0.0094
PRB61	1.88	0.0718	0.0560	0.0024	0.0112	0.0003	0.2732	0.0109
PRB72	1.31	0.0507	0.0523	0.0028	0.0114	0.0004	0.2554	0.0133

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2	PRB30	2.19	0.0825	0.0509	0.0018	0.0104	0.0002	0.2490	0.0077
3	PRB26	1.68	0.0634	0.0555	0.0029	0.0107	0.0003	0.2716	0.0133
4	PRB36	1.16	0.0439	0.0516	0.0023	0.0099	0.0003	0.2524	0.0103
5	PRB54	1.36	0.0512	0.0492	0.0017	0.0099	0.0003	0.2417	0.0078
6	PRB53	1.03	0.0390	0.0482	0.0021	0.0103	0.0003	0.2371	0.0095
7	PRB2	1.67	0.0628	0.0529	0.0019	0.0110	0.0002	0.2662	0.0085
8	PRB60	1.26	0.0482	0.0477	0.0025	0.0109	0.0003	0.2401	0.0119
9	PRB6	1.94	0.0732	0.0528	0.0021	0.0111	0.0003	0.2683	0.0095
10	PRB24	2.54	0.0955	0.0520	0.0018	0.0110	0.0002	0.2647	0.0080
11	PRB38	1.88	0.0709	0.0505	0.0020	0.0103	0.0002	0.2574	0.0090
12	PRB69	0.68	0.0261	0.0494	0.0021	0.0111	0.0003	0.2540	0.0102
13	PRB1	3.26	0.1224	0.0526	0.0019	0.0115	0.0002	0.2728	0.0084
14	PRB16	0.95	0.0357	0.0551	0.0027	0.0109	0.0003	0.2863	0.0130
15	PRB102	1.53	0.0618	0.0548	0.0029	0.0114	0.0004	0.2889	0.0149
16	PRB31	1.09	0.0412	0.0502	0.0025	0.0117	0.0003	0.2646	0.0122
17	PRB89	1.12	0.0447	0.0510	0.0028	0.0117	0.0004	0.2710	0.0144
18	PRB87	0.59	0.0235	0.0529	0.0023	0.0127	0.0004	0.2861	0.0117
19	PRB99	0.77	0.0312	0.0536	0.0028	0.0122	0.0005	0.2924	0.0146
20	PRB109	0.97	0.0398	0.0509	0.0026	0.0120	0.0004	0.2790	0.0135
21	PRB91	0.68	0.0273	0.0540	0.0035	0.0118	0.0005	0.2964	0.0188
22	PRB74	1.01	0.0392	0.0531	0.0024	0.0125	0.0004	0.2917	0.0123
23	PRB17	0.55	0.0205	0.0506	0.0018	0.0117	0.0003	0.2782	0.0086
24	PRB111	0.73	0.0301	0.0521	0.0038	0.0121	0.0006	0.2884	0.0204
25	PRB52	1.76	0.0665	0.0498	0.0019	0.0114	0.0003	0.2752	0.0098
26	PRB94	0.83	0.0331	0.0526	0.0027	0.0120	0.0004	0.2910	0.0144
27	PRB40	0.89	0.0340	0.0506	0.0034	0.0114	0.0004	0.2797	0.0179
28	PRB112	0.98	0.0402	0.0545	0.0030	0.0119	0.0005	0.3052	0.0160
29	PRB50	0.78	0.0294	0.0497	0.0026	0.0113	0.0004	0.2799	0.0136
30	PRB73	1.03	0.0400	0.0537	0.0027	0.0125	0.0004	0.3040	0.0148
31	PRB110	1.05	0.0432	0.0565	0.0032	0.0124	0.0005	0.3202	0.0175
32	PRB32	1.13	0.0426	0.0522	0.0019	0.0122	0.0003	0.2978	0.0100
33	PRB5	1.07	0.0405	0.0540	0.0022	0.0125	0.0003	0.3096	0.0112
34	PRB44	0.89	0.0337	0.0522	0.0026	0.0117	0.0004	0.2996	0.0139
35	PRB103	0.84	0.0342	0.0545	0.0033	0.0127	0.0005	0.3149	0.0184
36	PRB8	1.06	0.0401	0.0558	0.0025	0.0134	0.0003	0.3241	0.0130
37	PRB35	0.91	0.0343	0.0505	0.0025	0.0126	0.0004	0.2960	0.0135
38	PRB10	0.80	0.0300	0.0516	0.0020	0.0130	0.0003	0.3025	0.0103
39	PRB70	1.00	0.0435	0.0550	0.0123	0.0130	0.0015	0.3353	0.0730
40	PRB3	0.69	0.0260	0.0548	0.0020	0.0142	0.0003	0.3388	0.0109
41	PRB96	0.43	0.0172	0.0548	0.0024	0.0139	0.0005	0.3414	0.0143
42	PRB46	1.43	0.0541	0.0503	0.0018	0.0127	0.0003	0.3135	0.0101
43	PRB13	0.36	0.0137	0.0544	0.0018	0.0119	0.0003	0.3465	0.0101
44	PRB95	0.80	0.0319	0.0511	0.0023	0.0144	0.0005	0.3339	0.0141
45	PRB55	0.69	0.0264	0.0537	0.0041	0.0148	0.0007	0.3515	0.0256
46	GJ-1								
47	GJ1	0.03	0.0011	0.0603	0.0020	0.0328	0.0013	0.8242	0.0234
48	GJ10	0.03	0.0012	0.0589	0.0023	0.0291	0.0017	0.7886	0.0285
49	GJ11	0.03	0.0011	0.0602	0.0024	0.0351	0.0021	0.7978	0.0302
50	GJ12	0.03	0.0013	0.0587	0.0024	0.0300	0.0017	0.7852	0.0307
51	GJ2	0.03	0.0011	0.0614	0.0020	0.0282	0.0012	0.8137	0.0233
52	GJ3	0.03	0.0011	0.0595	0.0020	0.0306	0.0013	0.7795	0.0228
53	GJ4	0.03	0.0011	0.0586	0.0020	0.0274	0.0013	0.7841	0.0236
54	GJ5	0.03	0.0011	0.0591	0.0020	0.0283	0.0014	0.7951	0.0246

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2	GJ6	0.03	0.0011	0.0579	0.0021	0.0284	0.0014	0.7965	0.0255
3	GJ7	0.03	0.0011	0.0606	0.0022	0.0299	0.0016	0.8397	0.0284
4	GJ8	0.03	0.0011	0.0614	0.0022	0.0345	0.0017	0.8373	0.0283
5	GJ9	0.03	0.0011	0.0604	0.0023	0.0338	0.0018	0.7998	0.0280
6									
7	Plesovice								
8	PL1	0.10	0.0037	0.0532	0.0017	0.0169	0.0004	0.4111	0.0113
9	PL10	0.10	0.0038	0.0533	0.0020	0.0173	0.0006	0.3909	0.0137
10	PL11	0.10	0.0041	0.0540	0.0021	0.0165	0.0006	0.4040	0.0147
11	PL12	0.10	0.0043	0.0529	0.0021	0.0152	0.0006	0.3975	0.0151
12	PL2	0.10	0.0037	0.0523	0.0017	0.0165	0.0004	0.3902	0.0109
13	PL3	0.10	0.0037	0.0523	0.0017	0.0160	0.0004	0.3864	0.0110
14	PL4	0.10	0.0038	0.0508	0.0017	0.0153	0.0004	0.3742	0.0110
15	PL5	0.10	0.0037	0.0517	0.0017	0.0156	0.0004	0.3993	0.0120
16	PL6	0.10	0.0037	0.0530	0.0022	0.0143	0.0007	0.3955	0.0154
17	PL7	0.10	0.0038	0.0527	0.0019	0.0175	0.0005	0.3990	0.0132
18	PL8	0.10	0.0039	0.0525	0.0019	0.0166	0.0005	0.4001	0.0133
19	PL9	0.10	0.0038	0.0528	0.0019	0.0161	0.0005	0.3874	0.0132
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Возраст, млн лет									
$\frac{^{206}\text{Pb}}{^{238}\text{U}}$	1 σ (abs)	Rho	$\frac{^{207}\text{Pb}}{^{206}\text{Pb}}$	1 σ	$\frac{^{208}\text{Pb}}{^{232}\text{Th}}$	1 σ	$\frac{^{207}\text{Pb}}{^{235}\text{U}}$	1 σ	
0.0213	0.0006	0.6	127.6	112.8	135.6	4.0	135.6	6.0	
0.0236	0.0007	0.5	250.3	125.5	150.7	4.6	156.3	7.9	
0.0238	0.0009	0.3	15.3	268.7	161.8	8.8	143.7	15.9	
0.0240	0.0007	0.5	228.9	131.3	144.2	5.2	157.6	8.4	
0.0243	0.0008	0.5	205.6	155.9	151.1	5.0	158.1	10.0	
0.0244	0.0007	0.5	286.6	122.8	150.7	4.7	164.0	8.1	
0.0246	0.0007	0.7	118.8	102.5	156.2	4.5	154.5	6.1	
0.0247	0.0007	0.4	338.1	147.4	154.5	5.8	169.0	10.2	
0.0248	0.0008	0.4	340.6	184.3	162.3	6.8	169.7	13.1	
0.0250	0.0007	0.7	247.4	97.8	144.0	3.6	164.8	6.1	
0.0250	0.0007	0.4	258.2	152.6	135.2	5.3	165.5	10.2	
0.0250	0.0007	0.6	153.8	104.1	144.2	3.6	159.0	6.2	
0.0252	0.0007	0.7	136.2	92.6	146.5	3.6	159.0	5.5	
0.0253	0.0007	0.5	277.8	122.3	164.7	4.6	169.0	8.0	
0.0255	0.0007	0.6	396.6	108.7	146.2	4.1	178.2	7.7	
0.0256	0.0007	0.8	103.2	89.4	152.1	4.7	159.0	5.4	
0.0256	0.0007	0.8	166.9	79.4	149.0	3.4	163.3	4.7	
0.0256	0.0008	0.3	377.6	204.4	172.9	8.4	177.8	15.3	
0.0257	0.0007	0.6	1.9	113.5	148.5	4.0	153.8	6.5	
0.0270	0.0008	0.6	250.8	122.3	161.2	5.8	177.5	8.7	
0.0272	0.0007	0.5	46.5	132.9	165.5	4.7	164.5	8.3	
0.0272	0.0008	0.6	318.3	122.6	172.9	6.0	183.6	9.1	
0.0274	0.0008	0.6	388.8	110.4	167.4	5.0	190.0	8.4	
0.0278	0.0008	0.6	347.1	101.2	178.2	5.1	189.4	7.6	
0.0279	0.0008	0.5	230.9	125.6	182.9	6.1	181.1	9.0	
0.0281	0.0008	0.6	69.8	109.9	175.1	5.5	171.1	7.1	
0.0284	0.0008	0.5	345.7	115.0	181.7	5.6	192.9	8.7	
0.0286	0.0008	0.7	146.4	93.8	167.0	4.2	179.2	6.3	
0.0286	0.0008	0.7	264.9	89.9	170.4	4.8	188.0	6.5	
0.0287	0.0008	0.7	91.0	103.1	172.4	5.7	176.1	6.9	
0.0288	0.0008	0.6	240.4	120.9	172.7	6.0	187.1	8.9	
0.0289	0.0009	0.6	167.7	122.8	173.1	5.6	182.4	8.8	
0.0341	0.0009	0.6	299.8	113.0	192.3	5.8	223.3	9.7	
0.0344	0.0010	0.7	274.7	90.0	216.7	5.6	222.8	7.6	
0.0344	0.0010	0.7	386.5	93.1	221.7	6.0	233.0	8.4	
0.0346	0.0010	0.7	123.9	104.4	214.6	7.3	211.3	8.4	
0.0347	0.0010	0.6	345.1	101.9	218.8	6.2	231.2	9.2	
0.0348	0.0010	0.7	195.2	92.8	217.3	5.6	218.4	7.6	
0.0349	0.0009	0.7	146.8	94.2	205.0	5.2	214.8	7.4	
0.0351	0.0010	0.6	230.2	107.9	212.5	6.6	223.3	9.3	
0.0351	0.0010	0.4	169.5	153.4	224.1	6.8	218.1	12.9	
0.0352	0.0009	0.7	388.2	94.4	212.1	5.7	237.9	8.5	
0.0352	0.0010	0.8	176.8	90.3	216.4	6.6	219.0	7.4	
0.0353	0.0010	0.7	273.7	92.9	208.2	5.2	227.9	7.9	
0.0353	0.0010	0.8	298.7	87.0	209.7	5.5	230.3	7.6	
0.0354	0.0010	0.7	450.2	91.0	224.7	5.8	245.2	8.7	
0.0354	0.0010	0.6	298.7	119.1	229.2	7.0	231.0	10.7	

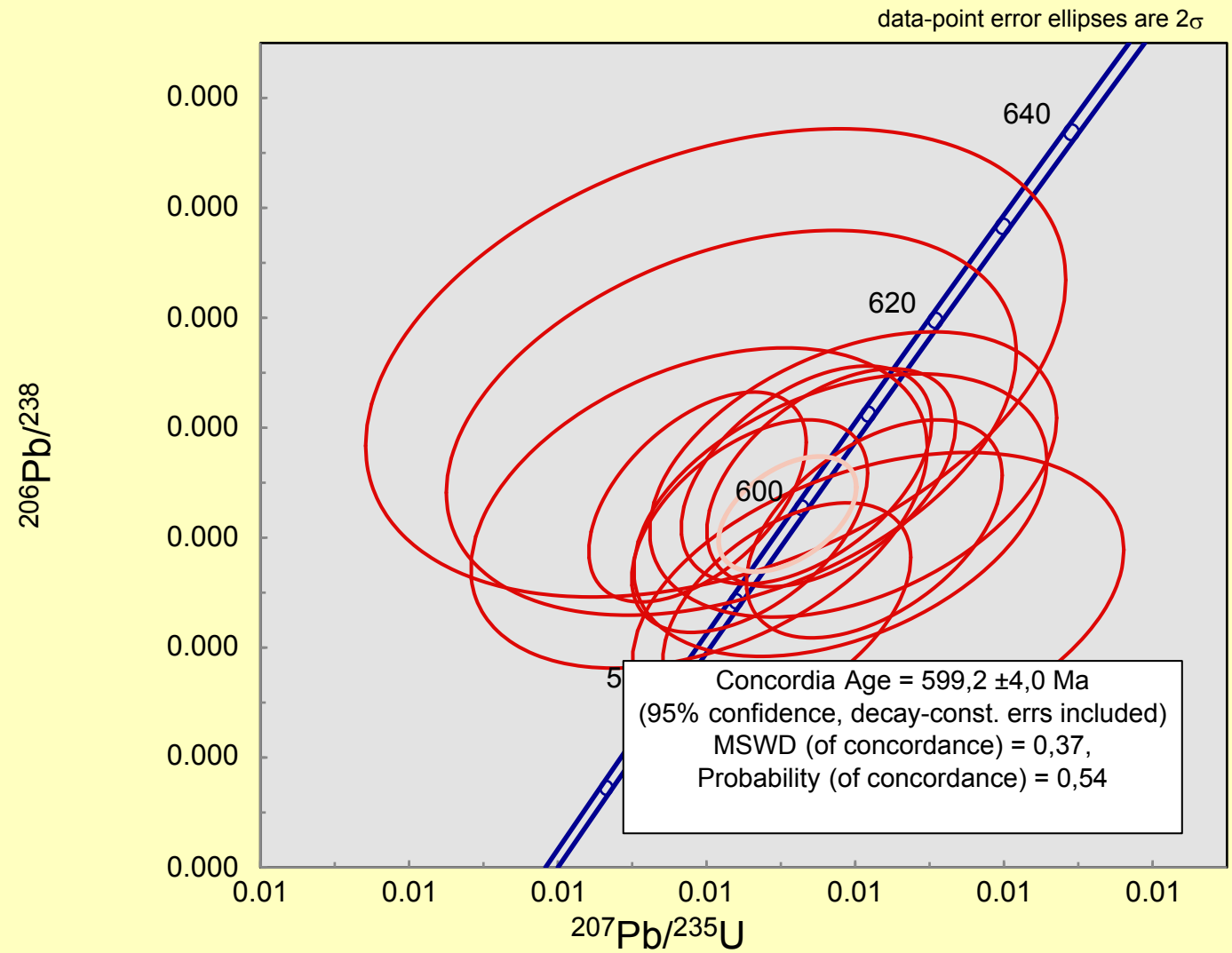
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2	0.0355	0.0009	0.8	236.8	78.9	210.0	4.6	225.7	6.3
3	0.0355	0.0010	0.6	431.7	112.5	215.5	5.7	243.9	10.6
4	0.0355	0.0010	0.7	267.0	97.9	198.8	5.2	228.5	8.3
5	0.0357	0.0010	0.8	155.5	80.8	199.3	4.9	219.8	6.4
6	0.0357	0.0010	0.7	107.7	98.9	206.4	5.6	216.0	7.8
7	0.0365	0.0009	0.8	323.4	80.7	221.8	4.8	239.7	6.8
8	0.0365	0.0011	0.6	83.4	119.9	218.1	6.4	218.5	9.8
9	0.0368	0.0010	0.7	321.5	87.4	223.3	4.9	241.3	7.6
10	0.0369	0.0010	0.9	285.4	76.3	221.1	4.8	238.5	6.4
11	0.0370	0.0010	0.8	219.3	86.8	206.7	4.9	232.6	7.3
12	0.0373	0.0011	0.7	166.6	96.4	223.9	6.5	229.8	8.3
13	0.0373	0.0011	0.7	166.6	96.4	223.9	6.5	229.8	8.3
14	0.0377	0.0010	0.8	309.9	78.8	231.9	4.9	244.9	6.7
15	0.0377	0.0010	0.6	417.2	105.7	219.0	6.2	255.6	10.3
16	0.0382	0.0011	0.6	402.7	115.4	228.6	7.9	257.7	11.7
17	0.0382	0.0011	0.6	402.7	115.4	228.6	7.9	257.7	11.7
18	0.0383	0.0010	0.6	202.3	110.8	234.5	6.5	238.4	9.8
19	0.0385	0.0011	0.6	242.6	122.6	235.7	8.0	243.5	11.5
20	0.0393	0.0011	0.7	322.2	94.7	255.7	8.1	255.5	9.2
21	0.0396	0.0012	0.6	352.4	112.3	245.5	8.9	260.4	11.4
22	0.0397	0.0012	0.6	238.0	111.5	240.6	8.7	249.9	10.7
23	0.0398	0.0012	0.5	370.6	141.1	236.3	10.3	263.6	14.7
24	0.0398	0.0011	0.7	332.5	97.6	250.9	7.2	259.9	9.7
25	0.0398	0.0011	0.7	332.5	97.6	250.9	7.2	259.9	9.7
26	0.0399	0.0010	0.8	220.8	79.6	234.9	5.5	249.2	6.9
27	0.0401	0.0013	0.5	291.1	157.8	243.5	11.8	257.3	16.1
28	0.0401	0.0011	0.8	185.0	88.0	229.7	5.8	246.8	7.8
29	0.0401	0.0012	0.6	311.6	113.5	240.1	8.4	259.3	11.3
30	0.0401	0.0012	0.5	220.1	147.4	230.0	8.5	250.4	14.2
31	0.0406	0.0012	0.6	391.6	116.9	239.5	9.2	270.5	12.4
32	0.0409	0.0011	0.6	180.6	115.3	227.3	7.3	250.6	10.8
33	0.0409	0.0011	0.6	180.6	115.3	227.3	7.3	250.6	10.8
34	0.0411	0.0012	0.6	358.2	110.5	250.4	7.8	269.5	11.5
35	0.0411	0.0013	0.6	469.5	121.5	249.1	9.6	282.1	13.5
36	0.0414	0.0011	0.8	293.0	82.7	245.2	5.8	264.6	7.8
37	0.0416	0.0011	0.7	370.2	88.2	251.1	6.0	273.9	8.7
38	0.0417	0.0012	0.6	293.0	108.7	235.1	7.1	266.1	10.8
39	0.0417	0.0012	0.6	293.0	108.7	235.1	7.1	266.1	10.8
40	0.0419	0.0013	0.5	392.0	130.3	254.5	10.3	277.9	14.2
41	0.0421	0.0011	0.6	444.7	94.9	269.4	6.8	285.0	10.0
42	0.0425	0.0012	0.6	219.2	109.0	252.8	7.2	263.2	10.6
43	0.0425	0.0011	0.7	266.5	85.7	261.4	6.2	268.4	8.1
44	0.0442	0.0026	0.3	411.3	433.8	261.5	29.1	293.6	55.5
45	0.0449	0.0011	0.8	402.3	79.6	284.2	6.6	296.3	8.3
46	0.0452	0.0013	0.7	402.3	95.1	279.2	9.8	298.3	10.9
47	0.0452	0.0012	0.8	207.4	80.3	254.5	6.1	276.9	7.8
48	0.0452	0.0012	0.8	207.4	80.3	254.5	6.1	276.9	7.8
49	0.0462	0.0012	0.9	387.4	73.0	238.3	5.6	302.1	7.6
50	0.0474	0.0014	0.7	246.7	98.5	288.3	9.2	292.6	10.7
51	0.0475	0.0015	0.4	359.0	162.0	297.8	13.5	305.8	19.2
52									
53	0.0992	0.0025	0.9	614.2	70.2	651.3	26.3	610.4	13.0
54	0.0970	0.0028	0.8	564.5	81.5	579.9	32.9	590.4	16.2
55	0.0962	0.0028	0.8	609.2	84.1	696.3	40.2	595.6	17.1
56	0.0962	0.0028	0.8	609.2	84.1	696.3	40.2	595.6	17.1
57	0.0970	0.0028	0.7	556.5	86.9	598.0	34.0	588.4	17.5
58	0.0961	0.0024	0.9	654.6	69.7	561.8	24.2	604.5	13.0
59	0.0950	0.0024	0.9	586.5	71.3	608.3	26.1	585.2	13.0
60	0.0970	0.0025	0.9	553.4	72.7	545.4	25.4	587.8	13.4
	0.0977	0.0026	0.8	569.2	73.6	563.9	26.7	594.0	13.9

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2	0.0998	0.0027	0.8	526.4	75.9	565.4	27.7	594.8	14.4
3	0.1005	0.0028	0.8	625.7	76.8	595.0	30.8	619.0	15.7
4	0.0990	0.0028	0.8	652.2	76.2	685.8	33.3	617.7	15.7
5	0.0960	0.0027	0.8	618.3	78.7	670.8	35.4	596.7	15.8
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9	0.0561	0.0014	0.9	337.5	72.1	337.9	8.4	349.7	8.2
10	0.0532	0.0015	0.8	339.5	82.2	346.2	11.6	335.0	10.0
11	0.0542	0.0015	0.8	371.5	84.3	331.6	11.8	344.5	10.7
12	0.0545	0.0016	0.8	324.9	88.3	305.0	11.5	339.8	11.0
13	0.0541	0.0014	0.9	298.6	72.8	331.3	8.4	334.5	8.0
14	0.0536	0.0014	0.9	299.3	73.2	321.0	8.4	331.8	8.1
15	0.0534	0.0014	0.9	231.6	75.3	307.3	8.4	322.8	8.1
16	0.0560	0.0015	0.9	273.0	75.4	312.1	8.7	341.1	8.7
17	0.0541	0.0015	0.7	330.4	92.5	285.9	14.2	338.4	11.2
18	0.0549	0.0015	0.8	316.3	79.0	350.6	10.5	340.9	9.5
19	0.0553	0.0015	0.8	308.1	79.2	332.0	10.1	341.7	9.6
20	0.0532	0.0015	0.8	318.2	80.7	322.5	10.5	332.4	9.6
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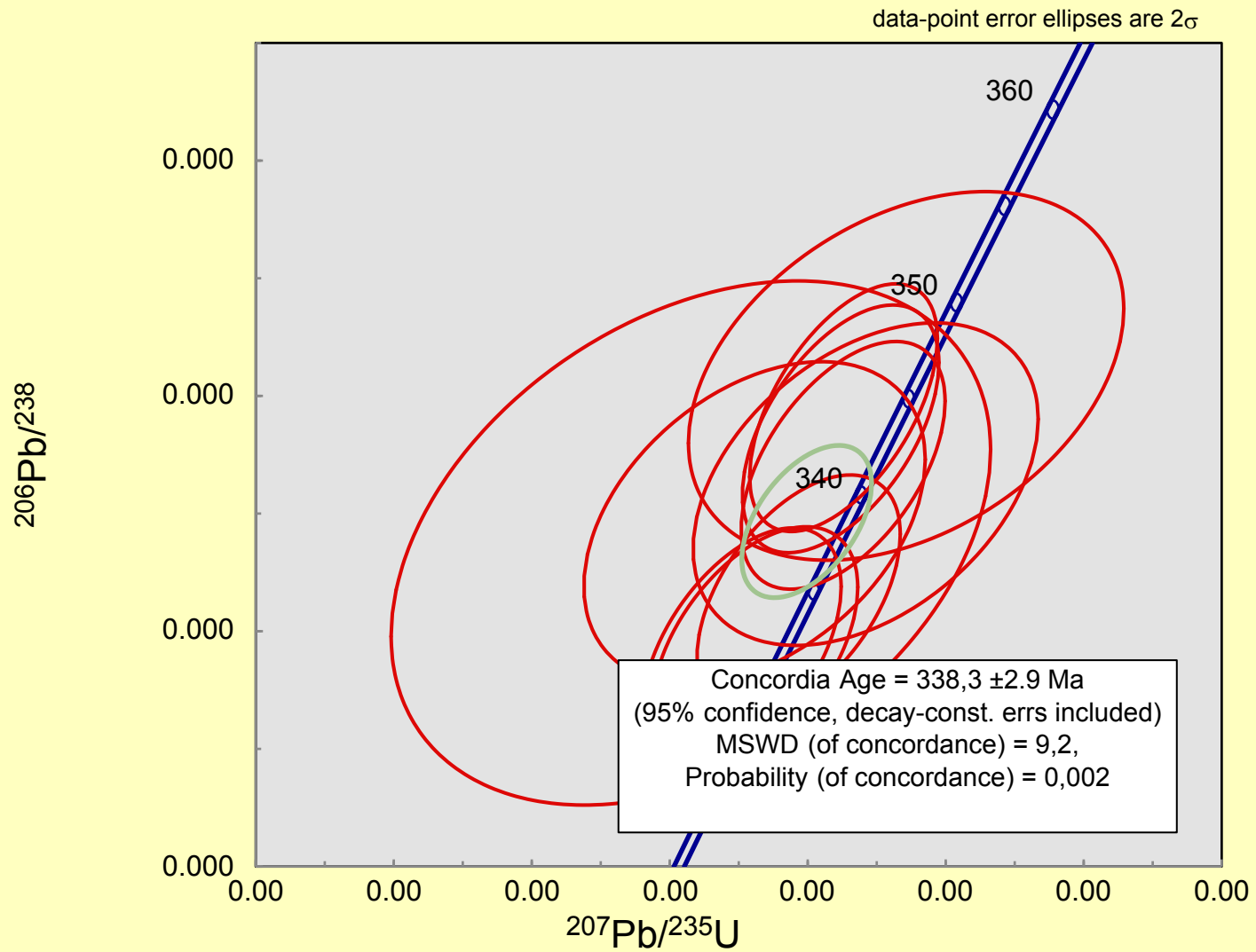
	$\frac{^{206}\text{Pb}}{^{238}\text{U}}$	1 σ	D, %
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9	136.1	3.9	-0.4
10	150.2	4.4	4.1
11	151.7	5.4	-5.3
12	152.8	4.6	3.1
13	154.9	4.8	2.1
14	155.6	4.6	5.4
15	156.8	4.4	-1.5
16	157.1	4.5	7.6
17	157.7	5.1	7.6
18	159.1	4.2	3.6
19	159.1	4.6	4.0
20	159.3	4.2	-0.2
21	160.6	4.3	-1.0
22	161.3	4.3	4.8
23	162.2	4.3	9.9
24	162.7	4.6	-2.3
25	163.0	4.2	0.2
26	163.1	5.1	9.0
27	163.8	4.3	-6.1
28	172.0	5.1	3.2
29	172.8	4.6	-4.8
30	173.3	5.1	5.9
31	174.4	5.0	8.9
32	177.0	5.0	7.0
33	177.3	5.1	2.1
34	178.5	5.0	-4.1
35	180.6	4.9	6.8
36	181.8	4.8	-1.4
37	181.9	5.1	3.4
38	182.4	5.2	-3.5
39	182.9	5.3	2.3
40	183.5	5.3	-0.6
41	216.1	5.9	3.3
42	218.0	6.0	2.2
43	218.1	6.1	6.8
44	219.2	6.3	-3.6
45	220.1	6.2	5.0
46	220.6	6.1	-1.0
47	221.2	5.9	-2.9
48	222.5	6.4	0.4
49	222.6	6.2	-2.0
50	222.9	5.8	6.7
51	222.9	6.2	-1.7
52	223.5	5.9	2.0
53	223.6	6.2	3.0
54	224.3	6.2	9.3
55	224.3	6.5	3.0

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2	224.6	5.7	0.5
3	224.8	6.1	8.5
4	224.8	5.9	1.6
5	225.9	5.9	-2.7
6	226.2	6.0	-4.5
7	231.2	5.8	3.7
8	231.2	6.5	-5.5
9	233.2	5.9	3.5
10	233.7	5.9	2.1
11	233.9	6.1	-0.6
12	236.0	6.6	-2.6
13	238.2	5.9	2.8
14	238.3	6.3	7.3
15	241.9	7.1	6.5
16	242.0	6.5	-1.5
17	243.5	7.1	0.0
18	248.2	7.0	2.9
19	250.2	7.3	4.1
20	251.0	7.3	-0.4
21	251.6	7.6	4.8
22	251.9	7.0	3.2
23	252.2	6.3	-1.2
24	253.5	8.0	1.5
25	253.5	6.7	-2.6
26	253.5	7.3	2.3
27	253.7	7.2	-1.3
28	256.6	7.6	5.4
29	258.2	7.0	-2.9
30	259.4	7.4	3.9
31	259.8	7.7	8.6
32	261.4	6.7	1.2
33	262.7	6.6	4.3
34	263.1	7.1	1.1
35	264.5	7.9	5.1
36	265.9	6.8	7.2
37	268.2	7.1	-1.9
38	268.6	6.7	-0.1
39	279.0	15.7	5.2
40	283.0	7.0	4.7
41	285.0	8.1	4.7
42	285.2	7.4	-2.9
43	291.1	7.2	3.8
44	298.2	8.4	-1.9
45	299.1	9.0	2.2
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47	609.4	14.6	0.2
48	596.9	16.1	-1.1
49	591.8	16.2	0.6
50	596.5	16.5	-1.4
51	591.2	14.3	2.2
52	584.8	14.3	0.1
53	596.7	14.8	-1.5
54	600.6	15.1	-1.1

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2	613.1	15.6	-3.0
3	617.3	16.3	0.3
4	608.3	16.2	1.5
5	590.9	15.9	1.0
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9	351.5	8.6	-0.5
10	334.3	9.2	0.2
11	340.4	9.4	1.2
12	341.9	9.6	-0.6
13	339.6	8.4	-1.5
14	336.3	8.4	-1.3
15	335.5	8.4	-3.8
16	351.2	8.9	-2.9
17	339.7	9.0	-0.4
18	344.7	9.3	-1.1
19	346.7	9.4	-1.4
20	334.4	9.1	-0.6
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#	Isotope ratio							
	$\frac{\text{Th}}{\text{U}}$	1 σ (abs)	$\frac{^{207}\text{Pb}}{^{206}\text{Pb}}$	1 σ (abs)	$\frac{^{208}\text{Pb}}{^{232}\text{Th}}$	1 σ (abs)	$\frac{^{207}\text{Pb}}{^{235}\text{U}}$	1 σ (abs)
GUS-14-6	number of sample		76 zircons					
PRB91	0.72	0.0153	0.0458	0.0023	0.0055	0.0002	0.1146	0.0056
PRB43	0.72	0.0102	0.0499	0.0018	0.0079	0.0002	0.1850	0.0063
PRB33	0.32	0.0045	0.0501	0.0010	0.0084	0.0001	0.1922	0.0033
PRB62	0.33	0.0057	0.0547	0.0024	0.0101	0.0004	0.2102	0.0088
PRB88	0.87	0.0176	0.0486	0.0019	0.0088	0.0003	0.1888	0.0071
PRB86	0.49	0.0099	0.0471	0.0019	0.0085	0.0003	0.1843	0.0073
PRB102	0.56	0.0146	0.0504	0.0025	0.0090	0.0004	0.1995	0.0096
PRB94	0.82	0.0182	0.0454	0.0020	0.0087	0.0003	0.1798	0.0076
PRB54	0.98	0.0138	0.0499	0.0014	0.0083	0.0001	0.1975	0.0053
PRB60	0.32	0.0054	0.0506	0.0022	0.0092	0.0003	0.2005	0.0082
PRB55	0.66	0.0093	0.0519	0.0010	0.0086	0.0001	0.2060	0.0037
PRB98	0.32	0.0086	0.0545	0.0045	0.0097	0.0007	0.2167	0.0176
PRB15	0.10	0.0014	0.0498	0.0010	0.0090	0.0002	0.2000	0.0037
PRB45	0.43	0.0060	0.0497	0.0011	0.0090	0.0002	0.2004	0.0042
PRB22	0.50	0.0072	0.0516	0.0017	0.0083	0.0002	0.2085	0.0067
PRB49	0.50	0.0072	0.0509	0.0014	0.0090	0.0002	0.2066	0.0052
PRB56	0.72	0.0122	0.0501	0.0022	0.0095	0.0003	0.2042	0.0086
PRB59	0.85	0.0144	0.0508	0.0019	0.0097	0.0003	0.2073	0.0076
PRB74	0.36	0.0062	0.0495	0.0016	0.0091	0.0003	0.2033	0.0064
PRB9	0.56	0.0079	0.0514	0.0014	0.0098	0.0002	0.2108	0.0056
PRB70	0.39	0.0067	0.0527	0.0025	0.0093	0.0004	0.2165	0.0099
PRB57	0.50	0.0086	0.0545	0.0025	0.0095	0.0003	0.2237	0.0099
PRB52	0.42	0.0059	0.0505	0.0011	0.0091	0.0002	0.2077	0.0042
PRB41	0.05	0.0008	0.0558	0.0011	0.0160	0.0004	0.2332	0.0041
PRB96	1.57	0.0369	0.0466	0.0021	0.0088	0.0004	0.1929	0.0085
PRB21	0.30	0.0043	0.0521	0.0012	0.0100	0.0002	0.2156	0.0047
PRB63	0.41	0.0067	0.0507	0.0015	0.0101	0.0003	0.2102	0.0059
PRB99	0.28	0.0069	0.0477	0.0022	0.0092	0.0004	0.1980	0.0089
PRB17	0.39	0.0056	0.0506	0.0013	0.0096	0.0002	0.2107	0.0051
PRB71	0.62	0.0106	0.0475	0.0018	0.0096	0.0003	0.1989	0.0074
PRB69	0.37	0.0062	0.0488	0.0017	0.0100	0.0003	0.2054	0.0068
PRB44	0.74	0.0106	0.0553	0.0017	0.0090	0.0002	0.2325	0.0067
PRB107	0.46	0.0133	0.0461	0.0025	0.0093	0.0005	0.1953	0.0102
PRB78	0.46	0.0084	0.0472	0.0021	0.0102	0.0003	0.2000	0.0088
PRB104	0.59	0.0156	0.0479	0.0023	0.0093	0.0004	0.2045	0.0095
PRB80	0.43	0.0078	0.0495	0.0014	0.0099	0.0003	0.2122	0.0059
PRB100	0.98	0.0244	0.0486	0.0022	0.0098	0.0004	0.2095	0.0094
PRB108	0.72	0.0212	0.0483	0.0025	0.0097	0.0005	0.2079	0.0107
PRB37	0.56	0.0085	0.0498	0.0031	0.0096	0.0004	0.2163	0.0129
PRB73	0.36	0.0061	0.0495	0.0013	0.0101	0.0002	0.2157	0.0056
PRB64	0.48	0.0080	0.0522	0.0016	0.0107	0.0003	0.2273	0.0066
PRB47	0.49	0.0103	0.0518	0.0069	0.0101	0.0009	0.2263	0.0299
PRB4	0.43	0.0061	0.0515	0.0011	0.0095	0.0002	0.2273	0.0047
PRB39	0.45	0.0074	0.0532	0.0042	0.0099	0.0005	0.2354	0.0183
PRB25	0.04	0.0006	0.0493	0.0009	0.0098	0.0004	0.2182	0.0035
PRB7	0.37	0.0055	0.0510	0.0021	0.0101	0.0003	0.2311	0.0093
PRB92	0.28	0.0091	0.0541	0.0067	0.0149	0.0015	0.2457	0.0297
PRB53	0.52	0.0074	0.0537	0.0013	0.0098	0.0002	0.2464	0.0056

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2	PRB20	0.29	0.0043	0.0558	0.0015	0.0145	0.0003	0.2655	0.0067
3	PRB77	0.38	0.0069	0.0471	0.0019	0.0110	0.0004	0.2318	0.0089
4	PRB27	0.26	0.0038	0.0470	0.0014	0.0112	0.0003	0.2343	0.0069
5	PRB79	0.31	0.0056	0.0506	0.0016	0.0120	0.0003	0.2566	0.0077
6	PRB95	0.83	0.0189	0.0563	0.0030	0.0113	0.0005	0.2877	0.0149
7	PRB26	1.11	0.0157	0.0534	0.0015	0.0114	0.0002	0.2760	0.0075
8	PRB29	0.80	0.0116	0.0519	0.0021	0.0123	0.0003	0.2717	0.0104
9	PRB23	0.72	0.0102	0.0502	0.0012	0.0117	0.0002	0.2667	0.0057
10	PRB85	0.64	0.0126	0.0545	0.0028	0.0124	0.0005	0.2959	0.0145
11	PRB76	0.54	0.0097	0.0557	0.0025	0.0133	0.0004	0.3131	0.0133
12	PRB97	0.90	0.0217	0.0539	0.0029	0.0133	0.0006	0.3227	0.0170
13	PRB101	0.51	0.0130	0.0480	0.0024	0.0165	0.0008	0.3295	0.0162
14	PRB61	0.37	0.0064	0.0532	0.0021	0.0166	0.0006	0.3757	0.0145
15	PRB109	0.75	0.0224	0.0490	0.0031	0.0160	0.0009	0.3645	0.0227
16	PRB93	1.65	0.0361	0.0541	0.0023	0.0172	0.0006	0.4269	0.0175
17	PRB24	0.60	0.0088	0.0602	0.0019	0.0205	0.0004	0.5061	0.0151
18	PRB50	0.25	0.0035	0.0569	0.0012	0.0191	0.0004	0.5411	0.0100
19	PRB67	0.36	0.0061	0.0556	0.0015	0.0231	0.0006	0.5628	0.0139
20	PRB87	0.83	0.0171	0.0572	0.0025	0.0236	0.0008	0.5824	0.0244
21	PRB84	0.24	0.0046	0.0537	0.0016	0.0219	0.0006	0.5649	0.0159
22	PRB42	0.43	0.0061	0.0581	0.0010	0.0212	0.0003	0.6278	0.0094
23	PRB103	0.77	0.0203	0.0543	0.0025	0.0239	0.0011	0.6162	0.0281
24	PRB34	0.82	0.0118	0.0668	0.0013	0.0411	0.0006	1.2616	0.0228
25	PRB110	0.97	0.0297	0.0663	0.0038	0.0421	0.0023	1.2739	0.0713
26	PRB14	0.86	0.0129	0.0702	0.0019	0.0427	0.0008	1.4308	0.0363
27	PRB16	0.35	0.0054	0.0755	0.0016	0.0505	0.0011	1.8130	0.0364
28	PRB51	0.58	0.0099	0.1096	0.0025	0.0888	0.0019	4.7380	0.0990
29	PRB90	0.25	0.0053	0.1427	0.0047	0.1568	0.0052	6.6377	0.2097
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35	Standart GJ-1								
36	GJ1	0.03	0.0005	0.0577	0.0010	0.0330	0.0013	0.7776	0.0120
37	GJ10	0.03	0.0007	0.0578	0.0019	0.0303	0.0018	0.7780	0.0251
38	GJ11	0.03	0.0008	0.0576	0.0024	0.0335	0.0021	0.7867	0.0313
39	GJ12	0.03	0.0010	0.0567	0.0028	0.0292	0.0021	0.7825	0.0385
40	GJ2	0.03	0.0005	0.0591	0.0011	0.0301	0.0013	0.7916	0.0130
41	GJ3	0.03	0.0006	0.0608	0.0011	0.0050	0.0016	0.8016	0.0136
42	GJ4	0.03	0.0006	0.0602	0.0011	0.0310	0.0014	0.8136	0.0137
43	GJ5	0.03	0.0006	0.0616	0.0012	0.0290	0.0015	0.8251	0.0141
44	GJ6	0.03	0.0006	0.0597	0.0011	0.0334	0.0015	0.8069	0.0138
45	GJ7	0.02	0.0006	0.0626	0.0022	0.0306	0.0019	0.8261	0.0270
46	GJ8	0.02	0.0006	0.0608	0.0018	0.0349	0.0021	0.8160	0.0227
47	GJ9	0.03	0.0006	0.0605	0.0017	0.0327	0.0018	0.8194	0.0224
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50	Standart Plesovice								
51	PL1	0.10	0.0015	0.0522	0.0008	0.0160	0.0003	0.3952	0.0056
52	PL10	0.10	0.0019	0.0488	0.0016	0.0152	0.0006	0.3604	0.0112
53	PL11	0.10	0.0024	0.0494	0.0020	0.0154	0.0007	0.3756	0.0144
54	PL12	0.10	0.0029	0.0504	0.0024	0.0167	0.0009	0.3731	0.0178
55	PL2	0.10	0.0015	0.0524	0.0009	0.0166	0.0003	0.3948	0.0058
56	PL3	0.10	0.0015	0.0527	0.0009	0.0151	0.0003	0.3951	0.0060
57	PL4	0.10	0.0015	0.0523	0.0009	0.0150	0.0003	0.3804	0.0059
58	PL5	0.10	0.0015	0.0529	0.0009	0.0154	0.0003	0.3887	0.0060
59	PL6	0.10	0.0015	0.0525	0.0009	0.0156	0.0003	0.3824	0.0061
60	PL7	0.09	0.0015	0.0532	0.0018	0.0169	0.0006	0.4043	0.0129

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2	PL8	0.08	0.0014	0.0514	0.0014	0.0185	0.0006	0.3823	0.0101
3	PL9	0.09	0.0016	0.0533	0.0014	0.0164	0.0005	0.3984	0.0102
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For Peer Review Only

Age, Ma									
$\frac{^{206}\text{Pb}}{^{238}\text{U}}$	1σ (abs)	Rho	Age, Ma						
			$\frac{^{207}\text{Pb}}{^{206}\text{Pb}}$	1σ	$\frac{^{208}\text{Pb}}{^{232}\text{Th}}$	1σ	$\frac{^{207}\text{Pb}}{^{235}\text{U}}$	1σ	
0.0181	0.0003	0.3	0.1	103.9	111	4.3	110.2	5.1	
0.0269	0.0003	0.3	190.7	80.5	158.3	3.3	172.4	5.4	
0.0278	0.0002	0.5	201.2	43.7	169.4	2.6	178.5	2.8	
0.0279	0.0004	0.3	401	94.2	202.7	7.2	193.7	7.4	
0.0282	0.0004	0.4	128.6	88.7	177.5	5.8	175.6	6.1	
0.0283	0.0004	0.3	56.1	94.6	171.4	5.9	171.7	6.2	
0.0287	0.0005	0.3	214.8	110.0	180.4	8.3	184.7	8.1	
0.0287	0.0004	0.3	0.1	65.1	175.5	6.6	167.8	6.6	
0.0288	0.0003	0.3	187.9	64.6	167.1	2.7	183	4.5	
0.0287	0.0004	0.3	222.2	95.6	185.7	6.7	185.5	6.9	
0.0288	0.0002	0.5	282.5	44.6	172.9	2.3	190.2	3.1	
0.0288	0.0006	0.3	392.9	176.2	194.8	14.4	199.2	14.7	
0.0292	0.0002	0.5	184.1	45.8	180.4	4.6	185.1	3.1	
0.0292	0.0003	0.4	182.1	51.4	181.9	3.0	185.4	3.5	
0.0293	0.0003	0.3	268.5	75.2	167.6	4.2	192.3	5.6	
0.0295	0.0003	0.4	234.1	60.0	180.1	3.3	190.7	4.3	
0.0296	0.0004	0.3	199.9	98.1	191.4	6.3	188.7	7.2	
0.0296	0.0004	0.3	230	85.6	194.1	5.7	191.3	6.4	
0.0298	0.0003	0.4	171.1	74.5	183.2	5.1	187.9	5.4	
0.0298	0.0003	0.4	256.4	62.7	196.2	3.5	194.2	4.7	
0.0298	0.0004	0.3	317.2	103.7	187.8	7.0	199	8.3	
0.0298	0.0004	0.3	391.2	99.2	191.2	6.9	205	8.2	
0.0299	0.0003	0.4	216.6	49.8	182.6	3.0	191.6	3.5	
0.0303	0.0003	0.5	444.6	42.2	320.8	8.4	212.9	3.4	
0.0300	0.0005	0.3	30.4	105.0	177.8	7.0	179.1	7.2	
0.0300	0.0003	0.4	290.5	52.1	201.4	3.8	198.3	3.9	
0.0301	0.0003	0.4	227.5	66.5	202.1	5.3	193.7	4.9	
0.0301	0.0005	0.3	82.3	106.9	185.8	8.4	183.4	7.6	
0.0302	0.0003	0.4	223.4	58.2	192.4	3.7	194.2	4.3	
0.0304	0.0004	0.3	71.4	90.1	193.2	5.3	184.2	6.3	
0.0305	0.0003	0.3	137.8	79.5	201.5	5.7	189.7	5.8	
0.0305	0.0003	0.3	422.9	65.6	182	3.4	212.3	5.5	
0.0307	0.0006	0.3	1.6	123.6	186.2	9.7	181.1	8.7	
0.0308	0.0004	0.3	56.6	104.8	205.4	6.9	185.1	7.4	
0.0310	0.0005	0.4	93.6	109.2	187.7	8.7	188.9	8.0	
0.0311	0.0003	0.4	172.7	66.6	199.5	5.2	195.4	5.0	
0.0312	0.0005	0.3	130.7	104.9	197	8.4	193.1	7.9	
0.0313	0.0006	0.3	111.5	119.3	196	10.1	191.8	9.0	
0.0315	0.0004	0.2	187.5	136.6	193.1	7.1	198.8	10.8	
0.0316	0.0003	0.4	172.3	62.1	202.1	4.8	198.3	4.6	
0.0316	0.0003	0.4	294.2	67.9	215.1	5.6	208	5.4	
0.0317	0.0008	0.2	274.5	281.2	203.6	17.7	207.2	24.7	
0.0320	0.0003	0.4	264.7	50.1	191.3	3.2	208	3.9	
0.0321	0.0005	0.2	338.5	170.2	199.3	10.3	214.6	15.1	
0.0321	0.0003	0.5	162.6	41.2	197.9	7.2	200.4	2.9	
0.0329	0.0004	0.3	239.8	92.9	203.3	6.6	211.1	7.6	
0.0329	0.0010	0.2	375.6	256.8	299.2	29.7	223.1	24.2	
0.0333	0.0003	0.4	356.6	53.6	197.7	3.4	223.6	4.5	

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2	0.0345	0.0003	0.4	445.4	58.1	290.8	6.0	239.1	5.4
3	0.0357	0.0004	0.3	51.4	93.0	220	7.1	211.7	7.4
4	0.0362	0.0004	0.3	47.4	72.0	225.8	6.1	213.7	5.6
5	0.0368	0.0004	0.4	222.9	70.7	240.6	6.7	231.9	6.2
6	0.0371	0.0006	0.3	463.2	114.5	226.6	9.5	256.7	11.7
7	0.0375	0.0004	0.4	345.8	63.6	229.2	3.5	247.5	6.0
8	0.0380	0.0004	0.3	281.4	88.5	247.3	5.4	244	8.3
9	0.0386	0.0003	0.4	202.9	52.7	235.8	3.4	240.1	4.6
10	0.0393	0.0006	0.3	393	108.8	249.2	9.2	263.2	11.3
11	0.0408	0.0005	0.3	440.9	94.9	266.7	8.7	276.6	10.3
12	0.0434	0.0007	0.3	365.9	116.5	266	11.7	284	13.0
13	0.0498	0.0008	0.3	98.3	115.9	331	15.3	289.1	12.4
14	0.0512	0.0006	0.3	337.6	88.4	332.5	11.0	323.9	10.7
15	0.0540	0.0011	0.3	147.7	142.4	321.6	17.9	315.5	16.9
16	0.0572	0.0008	0.3	375.1	91.6	344.8	12.2	360.9	12.4
17	0.0610	0.0006	0.3	610.6	66.2	410.8	8.5	415.8	10.2
18	0.0690	0.0006	0.5	487.4	44.0	381.9	7.7	439.2	6.6
19	0.0734	0.0008	0.4	435.6	57.0	461.3	10.8	453.3	9.0
20	0.0739	0.0010	0.3	497.3	92.9	471.8	16.0	466	15.6
21	0.0763	0.0009	0.4	358.4	64.7	437.5	12.3	454.7	10.3
22	0.0784	0.0006	0.5	534.5	37.0	423.7	5.6	494.7	5.9
23	0.0824	0.0013	0.4	381.9	100.8	477.9	21.5	487.5	17.6
24	0.1371	0.0012	0.5	831.7	40.6	814.9	10.8	828.6	10.2
25	0.1395	0.0027	0.3	814.3	114.5	833	44.3	834.1	31.8
26	0.1480	0.0015	0.4	933.3	54.2	844.5	14.8	901.9	15.1
27	0.1744	0.0016	0.5	1081	42.9	994.8	20.3	1050.2	13.1
28	0.3137	0.0033	0.5	1793.1	40.2	1720	35.4	1774	17.5
29	0.3374	0.0042	0.4	2259.6	55.4	2943.9	90.1	2064.4	27.9
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36	0.0977	0.0008	0.5	519.6	37.6	656.5	24.9	584.1	6.8
37	0.0975	0.0012	0.4	523.1	71.6	602.7	35.4	584.3	14.3
38	0.0991	0.0014	0.4	513.1	87.7	666.4	40.1	589.3	17.8
39	0.1002	0.0017	0.4	477.5	107.7	581.8	41.9	586.9	21.9
40	0.0972	0.0008	0.5	570.8	39.0	599	26.3	592.1	7.4
41	0.0957	0.0008	0.5	631.8	39.9	100.8	31.3	597.7	7.7
42	0.0981	0.0008	0.5	610.6	39.6	616.4	27.5	604.4	7.7
43	0.0972	0.0008	0.5	661.4	39.8	578.5	29.6	610.9	7.8
44	0.0981	0.0008	0.5	591.5	40.2	663.8	29.7	600.7	7.7
45	0.0958	0.0011	0.4	694.4	71.7	610	37.3	611.5	15.0
46	0.0974	0.0011	0.4	630.3	61.9	693.7	40.7	605.8	12.7
47	0.0982	0.0011	0.4	622.8	60.6	650.9	35.8	607.7	12.5
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51	0.0549	0.0004	0.6	296.1	36.1	320.7	5.6	338.2	4.0
52	0.0535	0.0006	0.4	139.2	74.3	304.3	11.0	312.5	8.4
53	0.0552	0.0008	0.4	165.1	89.6	308.9	13.1	323.8	10.6
54	0.0538	0.0009	0.4	211	108.6	334.7	17.3	321.9	13.1
55	0.0547	0.0004	0.5	301.2	37.4	332.2	6.2	337.9	4.2
56	0.0544	0.0004	0.5	316.2	38.4	302.8	6.2	338.1	4.4
57	0.0529	0.0004	0.5	296.2	39.0	301.6	6.3	327.4	4.3
58	0.0533	0.0004	0.5	325.5	38.8	309.3	6.4	333.4	4.4
59	0.0529	0.0004	0.5	306.9	39.8	313.8	6.7	328.8	4.5
60	0.0552	0.0006	0.4	335.8	74.5	338	12.1	344.7	9.3

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2	0.0539	0.0006	0.4	259.6	62.9	369.7	11.4	328.7	7.4
3	0.0543	0.0006	0.4	339.4	60.7	328.2	9.9	340.5	7.4
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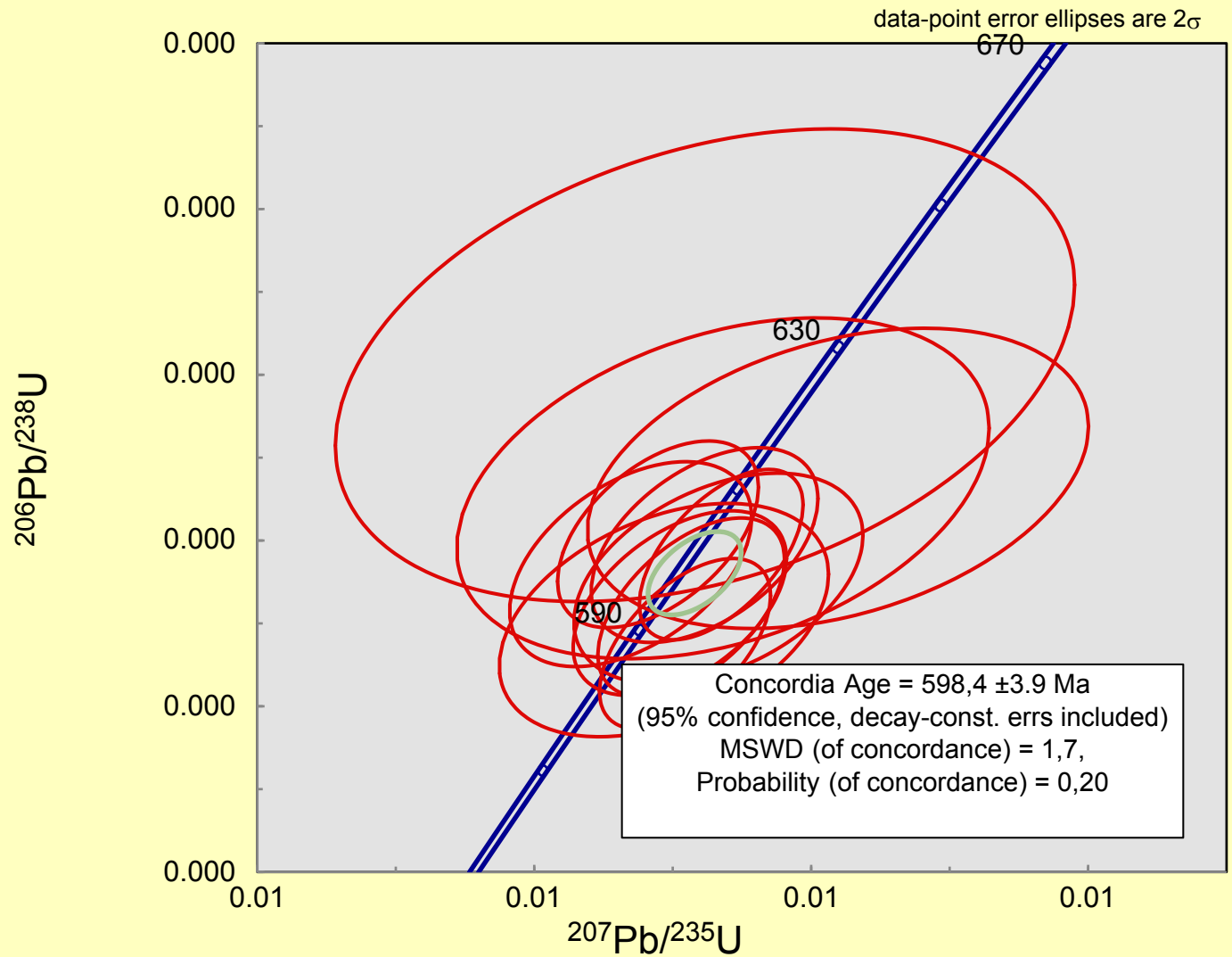
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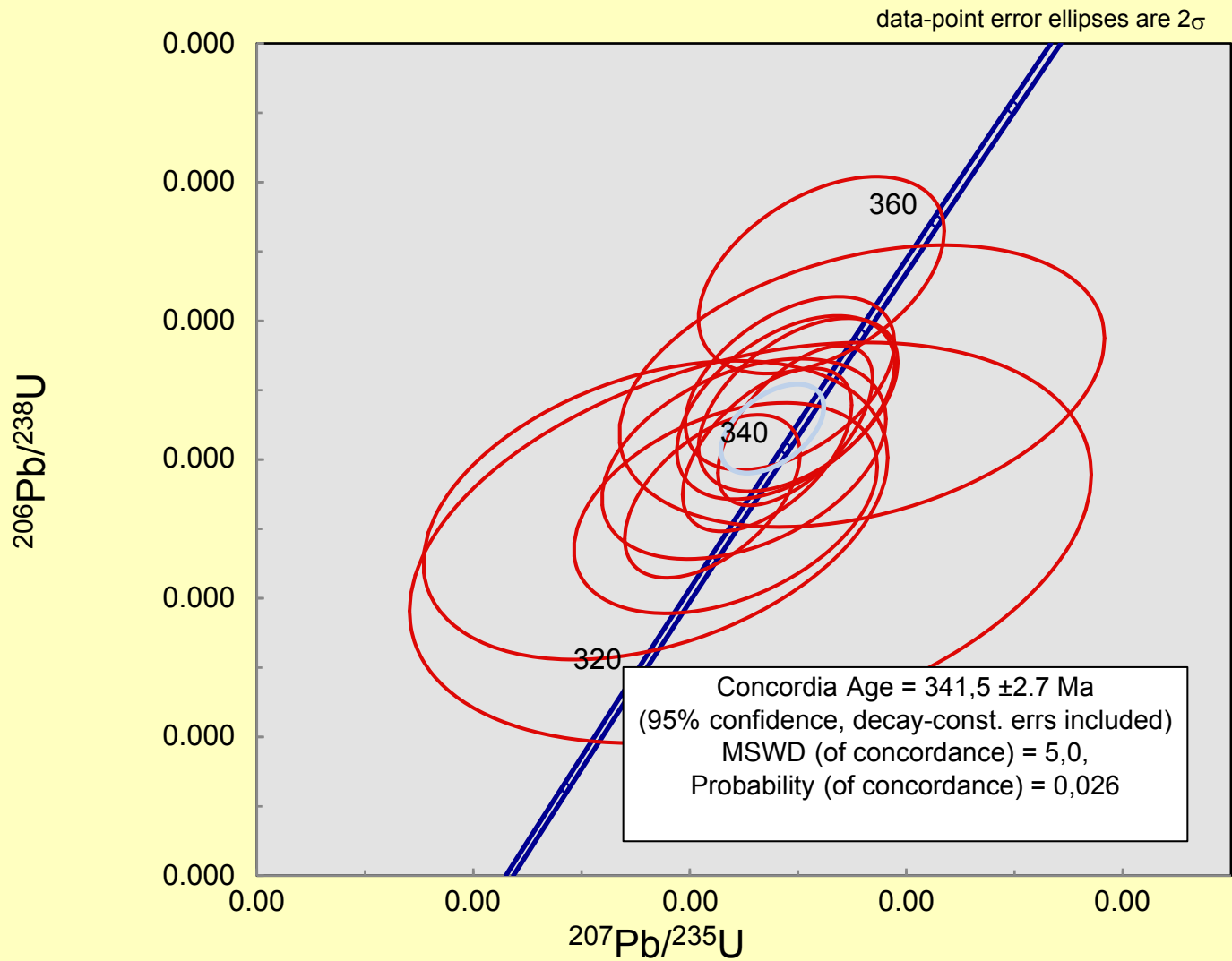
$\frac{^{206}\text{Pb}}{^{238}\text{U}}$	1 σ	D, %
115.9	1.7	-4.9
171.1	1.8	0.8
176.9	1.4	0.9
177.1	2.3	9.4
179	2.3	-1.9
180.1	2.3	-4.7
182.3	3.0	1.3
182.7	2.6	-8.2
182.7	1.7	0.2
182.7	2.3	1.5
183	1.5	3.9
183.2	4.0	8.7
185.3	1.5	-0.1
185.8	1.6	-0.2
186.3	1.9	3.2
187.3	1.7	1.8
187.8	2.4	0.5
188.2	2.2	1.6
189.2	2.1	-0.7
189.2	1.7	2.6
189.2	2.5	5.2
189.2	2.5	8.4
189.7	1.6	1.0
192.6	1.6	10.5
190.6	2.8	-6.0
190.7	1.6	4.0
191	2.0	1.4
191.3	2.9	-4.1
191.9	1.7	1.2
193	2.3	-4.6
193.9	2.2	-2.2
193.9	1.9	9.5
195.2	3.5	-7.2
195.2	2.5	-5.2
196.5	3.2	-3.9
197.2	2.1	-0.9
198.3	3.1	-2.6
198.4	3.5	-3.3
199.9	2.8	-0.6
200.4	2.0	-1.0
200.4	2.1	3.8
201.4	5.1	2.9
203.1	1.7	2.4
203.6	3.4	5.4
203.8	1.6	-1.7
208.7	2.3	1.1
208.8	6.1	6.8
211.3	1.8	5.8

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2	218.7	2.0	9.3
3	226.2	2.7	-6.4
4	229.2	2.2	-6.8
5	232.7	2.5	-0.3
6	234.6	3.8	9.4
7	237.4	2.2	4.3
8	240.3	2.7	1.5
9			
10	244	2.1	-1.6
11	248.8	3.6	5.8
12	257.5	3.4	7.4
13	274.1	4.5	3.6
14	313.1	5.0	-7.7
15			
16	322	3.9	0.6
17	338.8	6.6	-6.9
18	358.6	4.9	0.6
19	381.8	3.8	8.9
20	430.2	3.5	2.1
21	456.7	4.5	-0.7
22	459.4	6.2	1.4
23	473.8	5.1	-4.0
24	486.4	3.7	1.7
25	510.2	8.0	-4.4
26			
27	828	6.7	0.1
28	841.8	15.4	-0.9
29	889.7	8.4	1.4
30	1036	8.8	1.4
31	1758.8	16.3	0.9
32	1874.1	20.3	10.2
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36	601.1	4.6	-2.8
37	600	7.0	-2.6
38	609.1	8.4	-3.3
39	615.5	10.2	-4.6
40			
41	598	4.7	-1.0
42	589.1	4.7	1.5
43	603.2	4.7	0.2
44	597.7	4.7	2.2
45	603.5	4.8	-0.5
46	589.5	6.7	3.7
47	599.2	6.2	1.1
48			
49	603.5	6.2	0.7
50			
51	344.5	2.6	-1.8
52	336.1	3.9	-7.0
53	346.2	4.7	-6.5
54	337.5	5.6	-4.6
55	343.4	2.6	-1.6
56	341.5	2.6	-1.0
57			
58	332	2.6	-1.4
59	334.7	2.6	-0.4
60	332.1	2.6	-1.0
	346.2	3.9	-0.4

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2	338.5	3.4	-2.9
3	340.5	3.5	0.0
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#	Isotope ratio							
	$\frac{\text{Th}}{\text{U}}$	1 σ (abs)	$\frac{^{207}\text{Pb}}{^{206}\text{Pb}}$	1 σ (abs)	$\frac{^{208}\text{Pb}}{^{232}\text{Th}}$	1 σ (abs)	$\frac{^{207}\text{Pb}}{^{235}\text{U}}$	1 σ (abs)
GUS-14-1	number of sample		103 zircons					
PRB72	1.1555	0.0190	0.0500	0.0018	0.0082	0.0002	0.1731	0.0060
PRB57	2.1293	0.0350	0.0496	0.0015	0.0080	0.0001	0.1750	0.0051
PRB22	0.1512	0.0027	0.0503	0.0016	0.0086	0.0003	0.1786	0.0054
PRB90	0.4214	0.0071	0.0507	0.0018	0.0089	0.0002	0.1824	0.0062
PRB19	0.5837	0.0100	0.0489	0.0013	0.0084	0.0002	0.1769	0.0044
PRB5	0.7865	0.0160	0.0525	0.0025	0.0092	0.0004	0.1916	0.0085
PRB42	0.7710	0.0211	0.0494	0.0027	0.0079	0.0004	0.1820	0.0097
PRB80	0.6123	0.0100	0.0491	0.0011	0.0088	0.0002	0.1813	0.0039
PRB78	1.2360	0.0203	0.0530	0.0015	0.0087	0.0002	0.1965	0.0054
PRB103	0.6125	0.0106	0.0538	0.0026	0.0082	0.0003	0.1999	0.0093
PRB83	0.6243	0.0103	0.0483	0.0011	0.0088	0.0002	0.1799	0.0037
PRB31	0.6244	0.0129	0.0489	0.0020	0.0084	0.0003	0.1820	0.0072
PRB26	0.5240	0.0096	0.0528	0.0017	0.0086	0.0002	0.1985	0.0059
PRB87	0.6243	0.0104	0.0503	0.0015	0.0090	0.0002	0.1898	0.0055
PRB4	0.7588	0.0156	0.0512	0.0023	0.0093	0.0004	0.1942	0.0083
PRB39	0.8900	0.0216	0.0503	0.0025	0.0083	0.0004	0.1921	0.0092
PRB35	0.9537	0.0210	0.0505	0.0020	0.0085	0.0003	0.1930	0.0076
PRB71	0.6742	0.0111	0.0519	0.0014	0.0088	0.0002	0.1986	0.0052
PRB29	0.8749	0.0167	0.0533	0.0023	0.0085	0.0003	0.2040	0.0085
PRB2	0.4028	0.0085	0.0515	0.0024	0.0095	0.0004	0.1984	0.0087
PRB13	0.4246	0.0075	0.0516	0.0014	0.0090	0.0002	0.1988	0.0050
PRB40	0.7503	0.0186	0.0484	0.0024	0.0083	0.0004	0.1871	0.0091
PRB77	0.6807	0.0111	0.0503	0.0010	0.0088	0.0001	0.1953	0.0036
PRB37	0.1087	0.0026	0.0491	0.0021	0.0084	0.0004	0.1918	0.0079
PRB59	0.3126	0.0052	0.0495	0.0012	0.0090	0.0002	0.1937	0.0044
PRB36	0.4416	0.0101	0.0505	0.0021	0.0088	0.0004	0.1977	0.0079
PRB30	0.8557	0.0164	0.0492	0.0015	0.0088	0.0002	0.1929	0.0056
PRB92	0.3366	0.0056	0.0509	0.0014	0.0099	0.0002	0.1997	0.0053
PRB25	0.5354	0.0096	0.0495	0.0014	0.0090	0.0002	0.1947	0.0054
PRB55	0.7384	0.0277	0.0460	0.0036	0.0079	0.0006	0.1808	0.0141
PRB49	0.3659	0.0118	0.0547	0.0040	0.0084	0.0006	0.2156	0.0154
PRB48	0.2792	0.0088	0.0511	0.0033	0.0083	0.0005	0.2018	0.0129
PRB91	0.4262	0.0071	0.0502	0.0013	0.0099	0.0002	0.1986	0.0050
PRB43	0.5882	0.0164	0.0490	0.0027	0.0083	0.0004	0.1943	0.0106
PRB8	1.0195	0.0195	0.0489	0.0019	0.0097	0.0003	0.1939	0.0070
PRB24	0.4552	0.0082	0.0477	0.0018	0.0094	0.0003	0.1898	0.0071
PRB73	0.3299	0.0054	0.0513	0.0012	0.0092	0.0002	0.2044	0.0044
PRB110	0.8839	0.0152	0.0482	0.0013	0.0092	0.0002	0.1924	0.0052
PRB53	0.7311	0.0265	0.0500	0.0038	0.0081	0.0006	0.1994	0.0150
PRB50	0.4886	0.0158	0.0483	0.0031	0.0083	0.0005	0.1935	0.0122
PRB21	0.6680	0.0115	0.0516	0.0013	0.0094	0.0002	0.2073	0.0048
PRB65	0.8271	0.0136	0.0509	0.0014	0.0095	0.0002	0.2049	0.0054
PRB23	1.2473	0.0219	0.0531	0.0018	0.0091	0.0002	0.2136	0.0070
PRB18	0.5525	0.0095	0.0518	0.0018	0.0092	0.0002	0.2084	0.0069
PRB17	0.7132	0.0122	0.0547	0.0015	0.0097	0.0002	0.2203	0.0058
PRB45	0.4725	0.0139	0.0548	0.0041	0.0097	0.0006	0.2206	0.0160
PRB84	0.3867	0.0064	0.0487	0.0010	0.0093	0.0002	0.1964	0.0037
PRB79	0.5262	0.0086	0.0491	0.0009	0.0095	0.0001	0.1986	0.0034

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2	PRB58	0.5913	0.0097	0.0510	0.0011	0.0095	0.0001	0.2072	0.0042
3	PRB70	0.5597	0.0092	0.0521	0.0016	0.0096	0.0002	0.2115	0.0061
4	PRB47	0.5005	0.0154	0.0477	0.0032	0.0088	0.0006	0.1948	0.0128
5	PRB86	0.5701	0.0095	0.0505	0.0015	0.0096	0.0002	0.2076	0.0060
6	PRB3	0.4479	0.0094	0.0524	0.0023	0.0104	0.0005	0.2160	0.0091
7	PRB82	0.7329	0.0120	0.0496	0.0012	0.0098	0.0002	0.2057	0.0045
8	PRB81	0.7405	0.0122	0.0533	0.0013	0.0100	0.0002	0.2214	0.0053
9	PRB101	0.8361	0.0141	0.0499	0.0012	0.0100	0.0002	0.2076	0.0049
10	PRB102	0.2546	0.0044	0.0503	0.0015	0.0104	0.0003	0.2098	0.0061
11	PRB61	0.4714	0.0079	0.0544	0.0020	0.0101	0.0003	0.2272	0.0080
12	PRB14	0.2424	0.0043	0.0497	0.0015	0.0104	0.0003	0.2078	0.0059
13	PRB51	0.6696	0.0234	0.0465	0.0034	0.0085	0.0006	0.1945	0.0141
14	PRB46	0.4986	0.0150	0.0487	0.0029	0.0087	0.0005	0.2057	0.0121
15	PRB105	0.4605	0.0078	0.0495	0.0013	0.0100	0.0002	0.2091	0.0055
16	PRB109	0.4608	0.0080	0.0501	0.0018	0.0101	0.0003	0.2131	0.0073
17	PRB1	0.3950	0.0086	0.0528	0.0027	0.0107	0.0005	0.2276	0.0109
18	PRB89	0.4008	0.0067	0.0497	0.0014	0.0100	0.0002	0.2161	0.0059
19	PRB99	0.5015	0.0089	0.0514	0.0028	0.0113	0.0004	0.2250	0.0118
20	PRB106	0.6877	0.0117	0.0493	0.0014	0.0102	0.0003	0.2159	0.0057
21	PRB60	0.4029	0.0068	0.0547	0.0020	0.0103	0.0003	0.2405	0.0085
22	PRB108	0.2673	0.0046	0.0498	0.0013	0.0097	0.0003	0.2231	0.0057
23	PRB107	0.4130	0.0071	0.0503	0.0014	0.0109	0.0003	0.2258	0.0062
24	PRB56	0.4362	0.0072	0.0530	0.0010	0.0104	0.0002	0.2400	0.0043
25	PRB93	0.9444	0.0158	0.0522	0.0016	0.0111	0.0002	0.2407	0.0069
26	PRB98	0.9959	0.0170	0.0532	0.0023	0.0107	0.0003	0.2493	0.0105
27	PRB27	1.2138	0.0227	0.0541	0.0024	0.0104	0.0003	0.2539	0.0109
28	PRB10	0.4799	0.0090	0.0500	0.0019	0.0114	0.0004	0.2374	0.0086
29	PRB52	0.8075	0.0289	0.0511	0.0042	0.0096	0.0007	0.2427	0.0199
30	PRB97	1.2397	0.0209	0.0542	0.0018	0.0109	0.0003	0.2600	0.0085
31	PRB76	0.5244	0.0088	0.0564	0.0020	0.0128	0.0003	0.2767	0.0092
32	PRB74	0.8484	0.0141	0.0509	0.0019	0.0113	0.0002	0.2520	0.0092
33	PRB104	0.5237	0.0089	0.0484	0.0014	0.0119	0.0003	0.2397	0.0067
34	PRB68	0.7953	0.0131	0.0512	0.0016	0.0114	0.0002	0.2540	0.0075
35	PRB100	0.8421	0.0144	0.0541	0.0022	0.0120	0.0003	0.2713	0.0108
36	PRB85	0.5675	0.0094	0.0506	0.0012	0.0127	0.0002	0.2651	0.0061
37	PRB20	0.6194	0.0109	0.0536	0.0023	0.0116	0.0003	0.2822	0.0115
38	PRB64	0.8573	0.0141	0.0539	0.0015	0.0123	0.0002	0.2899	0.0075
39	PRB62	0.4843	0.0080	0.0527	0.0011	0.0137	0.0002	0.3328	0.0068
40	PRB9	0.4231	0.0082	0.0564	0.0024	0.0159	0.0006	0.3711	0.0152
41	PRB75	0.9673	0.0160	0.0537	0.0017	0.0160	0.0003	0.3716	0.0111
42	PRB54	0.7295	0.0271	0.0522	0.0043	0.0151	0.0011	0.3884	0.0316
43	PRB63	0.6364	0.0105	0.0517	0.0011	0.0167	0.0002	0.3864	0.0075
44	PRB67	0.7552	0.0124	0.0550	0.0013	0.0179	0.0003	0.4355	0.0093
45	PRB88	0.7582	0.0127	0.0557	0.0016	0.0190	0.0004	0.4520	0.0124
46	PRB69	0.8243	0.0137	0.0573	0.0016	0.0188	0.0003	0.4709	0.0129
47	PRB44	0.8507	0.0242	0.0554	0.0031	0.0168	0.0009	0.4562	0.0254
48	PRB94	0.6201	0.0106	0.0552	0.0018	0.0204	0.0005	0.4634	0.0145
49	PRB66	0.9359	0.0154	0.0579	0.0014	0.0199	0.0003	0.4948	0.0112
50	PRB16	0.3939	0.0068	0.0565	0.0014	0.0212	0.0005	0.5105	0.0118
51	PRB96	0.6416	0.0108	0.0543	0.0013	0.0236	0.0005	0.5481	0.0126
52	PRB41	0.6459	0.0174	0.0584	0.0030	0.0242	0.0012	0.6829	0.0348
53	PRB11	0.3084	0.0057	0.0605	0.0019	0.0305	0.0009	0.7416	0.0216
54	PRB28	0.6276	0.0118	0.0647	0.0018	0.0385	0.0010	1.0978	0.0284

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2	PRB12	0.5093	0.0096	0.0712	0.0024	0.0442	0.0013	1.3733	0.0436
3	PRB7	0.6658	0.0131	0.1092	0.0037	0.0920	0.0032	4.5354	0.1448
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5	Standart GJ-1								
6	GJ1	0.0268	0.0007	0.0627	0.0028	0.0361	0.0021	0.8597	0.0370
7	GJ10	0.0272	0.0005	0.0587	0.0012	0.0344	0.0012	0.7947	0.0148
8	GJ11	0.0268	0.0005	0.0601	0.0013	0.0347	0.0013	0.8115	0.0167
9	GJ12	0.0272	0.0005	0.0584	0.0014	0.0324	0.0012	0.7848	0.0179
10	GJ2	0.0269	0.0006	0.0610	0.0017	0.0312	0.0014	0.8165	0.0213
11	GJ3	0.0268	0.0006	0.0603	0.0013	0.0307	0.0013	0.8026	0.0157
12	GJ4	0.0295	0.0007	0.0601	0.0019	0.0291	0.0014	0.7968	0.0243
13	GJ5	0.0299	0.0009	0.0598	0.0029	0.0319	0.0019	0.8181	0.0393
14	GJ6	0.0314	0.0011	0.0576	0.0039	0.0283	0.0022	0.8117	0.0545
15	GJ7	0.0275	0.0005	0.0607	0.0010	0.0329	0.0010	0.8175	0.0121
16	GJ8	0.0268	0.0005	0.0611	0.0010	0.0312	0.0011	0.8045	0.0126
17	GJ9	0.0280	0.0005	0.0607	0.0011	0.0316	0.0011	0.8067	0.0138
18									
19	Standart Plesovice								
20									
21	PL1	0.0865	0.0019	0.0543	0.0026	0.0179	0.0010	0.4118	0.0183
22	PL10	0.0892	0.0015	0.0529	0.0011	0.0166	0.0004	0.4000	0.0075
23	PL11	0.0892	0.0015	0.0527	0.0012	0.0164	0.0004	0.3977	0.0082
24	PL12	0.0890	0.0015	0.0518	0.0012	0.0174	0.0005	0.4043	0.0093
25	PL2	0.0862	0.0016	0.0524	0.0015	0.0169	0.0006	0.3900	0.0107
26	PL3	0.0881	0.0015	0.0524	0.0011	0.0165	0.0004	0.3985	0.0079
27	PL4	0.0900	0.0018	0.0526	0.0016	0.0152	0.0005	0.3866	0.0115
28	PL5	0.0952	0.0025	0.0509	0.0024	0.0144	0.0007	0.3737	0.0175
29	PL6	0.0981	0.0033	0.0538	0.0036	0.0155	0.0011	0.3912	0.0257
30	PL7	0.0938	0.0016	0.0531	0.0009	0.0159	0.0003	0.3995	0.0058
31	PL8	0.0882	0.0015	0.0528	0.0009	0.0164	0.0004	0.3943	0.0064
32	PL9	0.0899	0.0015	0.0521	0.0010	0.0167	0.0004	0.3842	0.0066
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$\frac{^{206}\text{Pb}}{^{238}\text{U}}$	1σ (abs)	Rho	Age, Ma						
			$\frac{^{207}\text{Pb}}{^{206}\text{Pb}}$	1σ	$\frac{^{208}\text{Pb}}{^{232}\text{Th}}$	1σ	$\frac{^{207}\text{Pb}}{^{235}\text{U}}$	1σ	
0.0251	0.0003	0.3	194.6	81.75	164.4	3.03	162.1	5.22	
0.0256	0.0003	0.4	175.3	69.01	161.6	2.17	163.7	4.38	
0.0257	0.0003	0.3	209.7	70.96	173.3	5.95	166.9	4.62	
0.0261	0.0003	0.3	226.6	78.88	179.7	4.81	170.1	5.29	
0.0263	0.0003	0.4	142.3	59.74	169.7	3.32	165.4	3.75	
0.0265	0.0004	0.3	307.7	102.68	185.6	7.75	178	7.28	
0.0267	0.0005	0.3	165.4	121.69	158.5	8.17	169.7	8.33	
0.0268	0.0003	0.4	150.8	52.2	177.3	2.98	169.2	3.34	
0.0269	0.0003	0.4	328.5	63.38	174.9	2.96	182.2	4.55	
0.0270	0.0004	0.3	362.2	104.26	164.6	5.69	185	7.9	
0.0270	0.0003	0.5	115.9	50.25	176.6	2.96	167.9	3.16	
0.0270	0.0004	0.3	140.5	93.07	169.9	5.82	169.7	6.19	
0.0273	0.0003	0.4	320.4	69.32	172.6	4.41	183.8	5.03	
0.0274	0.0003	0.4	207.6	68.8	180.7	3.91	176.5	4.72	
0.0275	0.0004	0.3	251.3	99.39	186.5	7.93	180.2	7.03	
0.0277	0.0005	0.3	208.3	109.54	167.8	7.41	178.5	7.83	
0.0277	0.0004	0.4	218.9	90.9	170.5	6.28	179.2	6.46	
0.0277	0.0003	0.4	281.5	61.77	177.7	3.21	184	4.43	
0.0278	0.0004	0.3	339.6	94	171.4	5.16	188.5	7.14	
0.0279	0.0004	0.3	264.3	102.11	190.7	8.88	183.7	7.36	
0.0280	0.0003	0.4	266.9	60.23	180.3	4.37	184.1	4.26	
0.0280	0.0005	0.3	117.9	112.38	167.6	7.62	174.1	7.74	
0.0281	0.0003	0.5	209.1	44.91	177.3	2.67	181.1	3.05	
0.0283	0.0004	0.4	153	96.31	169.6	7.73	178.1	6.76	
0.0284	0.0003	0.4	170.9	54.49	180	3.48	179.8	3.7	
0.0284	0.0004	0.4	218.1	92	176.7	7.01	183.1	6.69	
0.0284	0.0003	0.4	158	68.63	177.3	4.69	179.1	4.73	
0.0285	0.0003	0.4	234.8	62.2	198.8	4.68	184.9	4.45	
0.0285	0.0003	0.4	171.7	66.73	180.6	4.18	180.6	4.62	
0.0285	0.0007	0.3	0.1	175.07	158.4	11.76	168.8	12.1	
0.0286	0.0007	0.3	400.1	154.39	169.8	11.75	198.2	12.89	
0.0286	0.0006	0.3	246.7	141.87	167.4	10.7	186.6	10.88	
0.0287	0.0003	0.4	204.8	59.65	198.5	4.26	183.9	4.21	
0.0288	0.0005	0.3	148.7	124.36	166.3	8.85	180.3	8.98	
0.0288	0.0004	0.3	140.6	86.44	194.7	6.63	179.9	5.95	
0.0288	0.0003	0.3	84.4	89.58	188.2	5.37	176.4	6.01	
0.0289	0.0003	0.4	255	51.22	184.7	3.46	188.8	3.68	
0.0289	0.0003	0.4	109.5	64.57	185.7	4.54	178.6	4.41	
0.0289	0.0007	0.3	195.7	166.1	162.9	11.69	184.6	12.68	
0.0291	0.0006	0.3	112.7	143.24	167.3	10.51	179.6	10.38	
0.0292	0.0003	0.4	266.7	54.97	188.5	3.54	191.3	4.02	
0.0292	0.0003	0.4	238.2	62.3	190.1	3.1	189.3	4.54	
0.0292	0.0003	0.3	332.7	74.95	183.1	3.86	196.6	5.81	
0.0292	0.0003	0.3	274.9	77.09	184.8	4.61	192.2	5.81	
0.0292	0.0003	0.4	399.1	59.85	194.6	3.99	202.1	4.8	
0.0292	0.0006	0.3	403.3	157.41	194.2	12.54	202.4	13.33	
0.0292	0.0003	0.5	134.6	46.76	186.5	3.2	182.1	3.16	
0.0293	0.0003	0.5	153.5	42.24	190.9	2.85	183.9	2.85	

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2	0.0295	0.0003	0.5	240.4	48.48	191.5	2.76	191.2	3.49
3	0.0295	0.0003	0.4	287.6	66.92	193.7	3.92	194.8	5.09
4	0.0296	0.0006	0.3	83.9	151.1	177.2	10.99	180.7	10.86
5	0.0298	0.0003	0.4	217.7	68.23	193.1	4.24	191.5	5.05
6	0.0299	0.0004	0.3	301.8	98.32	208.5	9.28	198.5	7.61
7	0.0301	0.0003	0.4	177	53.32	196.1	3.33	189.9	3.82
8	0.0301	0.0003	0.4	343.2	55.76	200.6	3.55	203	4.39
9	0.0302	0.0003	0.4	190.5	56.2	201	4.28	191.6	4.11
10	0.0303	0.0003	0.4	209.1	68.77	209.3	6	193.4	5.15
11	0.0303	0.0003	0.3	385.9	78.93	202.6	5.19	207.9	6.58
12	0.0303	0.0003	0.4	181.5	68.06	209.4	5.86	191.7	4.96
13	0.0303	0.0003	0.4	181.5	68.06	209.4	5.86	191.7	4.96
14	0.0304	0.0007	0.3	22.5	165.56	171.7	11.88	180.5	11.94
15	0.0306	0.0006	0.3	133.9	134.27	175.8	10.25	189.9	10.21
16	0.0306	0.0003	0.4	171.8	62.05	200.3	4.82	192.8	4.58
17	0.0309	0.0004	0.3	197.4	80.22	203.9	6.02	196.1	6.12
18	0.0313	0.0005	0.3	318.4	110.22	215.7	10.74	208.2	9.04
19	0.0315	0.0003	0.4	180.2	64.63	201.3	4.66	198.6	4.9
20	0.0315	0.0003	0.4	180.2	64.63	201.3	4.66	198.6	4.9
21	0.0318	0.0005	0.3	258.1	118.68	226.4	8.61	206.1	9.74
22	0.0318	0.0003	0.4	160.5	62.9	205.3	4.92	198.4	4.76
23	0.0318	0.0003	0.4	160.5	62.9	205.3	4.92	198.4	4.76
24	0.0319	0.0004	0.3	400.1	78.88	207.9	5.79	218.9	6.92
25	0.0325	0.0004	0.4	185.1	60.86	195	5.28	204.5	4.75
26	0.0326	0.0004	0.4	208.9	65	218.8	5.66	206.7	5.16
27	0.0328	0.0003	0.5	327.6	42.97	208.2	2.99	218.4	3.51
28	0.0334	0.0004	0.4	293.6	66.29	223.3	4.62	219	5.62
29	0.0340	0.0004	0.3	338.2	95.19	214.1	5.74	226	8.54
30	0.0340	0.0005	0.3	376.5	96.34	209.4	5.79	229.8	8.84
31	0.0340	0.0005	0.3	376.5	96.34	209.4	5.79	229.8	8.84
32	0.0345	0.0004	0.3	193.3	85.97	229	7.75	216.3	7.08
33	0.0345	0.0009	0.3	243	180.06	194	14.23	220.6	16.28
34	0.0348	0.0004	0.4	380.7	74.22	218.8	4.93	234.6	6.85
35	0.0356	0.0004	0.3	466.9	74.87	256.8	6.14	248	7.33
36	0.0359	0.0004	0.3	235.4	84.64	226.3	4.89	228.2	7.44
37	0.0359	0.0004	0.4	117.3	67.28	239.1	5.84	218.1	5.51
38	0.0360	0.0004	0.4	250.5	69.29	228.9	4.22	229.8	6.08
39	0.0364	0.0005	0.3	373.4	89.46	241	6.52	243.8	8.65
40	0.0364	0.0005	0.3	373.4	89.46	241	6.52	243.8	8.65
41	0.0380	0.0004	0.4	224	54.95	254.2	4.68	238.7	4.89
42	0.0382	0.0005	0.3	354	92.51	233.7	6.69	252.4	9.13
43	0.0390	0.0004	0.4	365.3	59.81	247.4	4.01	258.5	5.88
44	0.0458	0.0004	0.4	315.5	48.57	275.5	4.41	291.7	5.18
45	0.0477	0.0006	0.3	467.5	92.66	319.6	12.24	320.5	11.27
46	0.0502	0.0005	0.4	357.2	68.49	321.3	5.88	320.8	8.2
47	0.0540	0.0014	0.3	295.4	176	303.7	22.73	333.2	23.14
48	0.0542	0.0005	0.5	272.9	46.48	335.6	4.75	331.7	5.45
49	0.0542	0.0005	0.5	272.9	46.48	335.6	4.75	331.7	5.45
50	0.0574	0.0005	0.4	411.7	49.16	359	5.46	367.1	6.59
51	0.0588	0.0006	0.4	441.2	62.13	379.7	7.79	378.7	8.65
52	0.0596	0.0006	0.4	501.8	62.44	376.6	6.77	391.8	8.92
53	0.0597	0.0011	0.3	429.1	121.26	336.3	18.15	381.6	17.71
54	0.0609	0.0007	0.4	419.6	70.3	407.8	9.75	386.6	10.04
55	0.0619	0.0006	0.4	526.7	51.82	397.7	5.99	408.2	7.6
56	0.0655	0.0007	0.4	472.7	53.72	423.9	9.06	418.8	7.92
57	0.0655	0.0007	0.4	472.7	53.72	423.9	9.06	418.8	7.92
58	0.0732	0.0007	0.4	381.7	52.95	472.2	9.69	443.7	8.24
59	0.0848	0.0015	0.3	545.4	109.35	484.1	24.21	528.5	21.02
60	0.0889	0.0010	0.4	620.5	64.74	607.3	17.73	563.3	12.59
	0.1231	0.0013	0.4	764.1	56.12	764.4	18.61	752.3	13.76

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2	0.1400	0.0017	0.4	962.2	66.41	874.3	25.63	877.6	18.65
3	0.3012	0.0037	0.4	1786.6	60.31	1779.3	60.01	1737.5	26.57
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6	0.0995	0.0015	0.3	697.7	93.82	715.9	41.4	629.9	20.19
7	0.0982	0.0009	0.5	556	42.77	682.7	23.75	593.8	8.39
8	0.0979	0.0010	0.5	607.6	46.3	689.7	25.09	603.3	9.38
9	0.0974	0.0010	0.5	545.4	51.05	643.5	24.15	588.2	10.16
10	0.0971	0.0010	0.4	639.2	58.49	620.9	27.46	606.1	11.93
11	0.0965	0.0009	0.5	615	44.7	611.6	25.07	598.3	8.87
12	0.0961	0.0012	0.4	608.4	66.88	579.9	27.38	595	13.73
13	0.0993	0.0017	0.4	595.2	102.89	633.7	37.52	607	21.94
14	0.1022	0.0023	0.3	514.7	141.86	564	42.88	603.4	30.56
15	0.0977	0.0008	0.6	627.9	34.72	654.2	19.97	606.7	6.75
16	0.0955	0.0008	0.6	641.1	36.36	620.5	20.99	599.3	7.1
17	0.0964	0.0009	0.5	627.3	39.17	629.1	22.17	600.6	7.74
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21	0.0551	0.0008	0.3	382.2	101.63	357.6	18.78	350.2	13.17
22	0.0548	0.0005	0.5	325.8	44.71	333.6	7.81	341.7	5.45
23	0.0548	0.0005	0.5	314.5	48.72	328.7	8.33	340	5.97
24	0.0567	0.0006	0.4	274.1	53.9	349.5	9.63	344.8	6.71
25	0.0540	0.0006	0.4	301.8	64.82	339.3	11.25	334.4	7.83
26	0.0551	0.0005	0.5	304.8	47.47	329.8	8.42	340.6	5.73
27	0.0533	0.0006	0.4	311.3	68.37	304	10.54	331.9	8.39
28	0.0533	0.0009	0.4	235.4	106.51	289.7	14.68	322.4	12.96
29	0.0528	0.0012	0.3	361	142.09	310.7	20.95	335.2	18.78
30	0.0545	0.0005	0.6	334.8	36.05	318.8	5.65	341.3	4.24
31	0.0541	0.0005	0.5	319.8	39.37	329.2	6.9	337.5	4.64
32	0.0535	0.0005	0.5	288.9	41.83	334.1	7.2	330.1	4.86
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$\frac{^{206}\text{Pb}}{^{238}\text{U}}$	1σ	D, %
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159.8	1.75	1.4
162.9	1.64	0.5
163.8	1.72	1.9
166	1.85	2.5
167	1.62	-1.0
168.4	2.38	5.7
170.1	3.03	-0.2
170.4	1.6	-0.7
171	1.73	6.5
171.4	2.34	7.9
171.6	1.6	-2.2
171.8	2.25	-1.2
173.3	1.89	6.1
174.1	1.83	1.4
174.9	2.44	3.0
176.2	2.79	1.3
176.2	2.42	1.7
176.4	1.74	4.3
176.6	2.28	6.7
177.6	2.56	3.4
177.7	1.8	3.6
178.3	2.87	-2.4
178.9	1.61	1.2
180	2.61	-1.1
180.4	1.67	-0.3
180.4	2.55	1.5
180.6	2	-0.8
180.9	1.85	2.2
181.2	1.88	-0.3
181.4	4.57	-6.9
181.8	4.07	9.0
181.9	3.8	2.6
182.2	1.83	0.9
182.7	3.32	-1.3
182.9	2.25	-1.6
183.3	2.12	-3.8
183.5	1.7	2.9
183.9	1.97	-2.9
183.9	4.48	0.4
184.8	3.91	-2.8
185.2	1.78	3.3
185.3	1.81	2.2
185.4	2.04	6.0
185.5	2.03	3.6
185.6	1.86	8.9
185.6	4.01	9.1
185.7	1.7	-1.9
186.2	1.65	-1.2

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2	187.1	1.68	2.2
3	187.2	1.91	4.1
4	188.2	3.92	-4.0
5	189.3	1.98	1.2
6	190	2.66	4.5
7	190.9	1.81	-0.5
8	191.1	1.86	6.2
9	191.6	1.93	0.0
10	192.1	2.08	0.7
11	192.4	2.15	8.1
12	192.5	2.01	-0.4
13	192.8	4.52	-6.4
14	194.5	3.82	-2.4
15	194.5	2.03	-0.9
16	196	2.29	0.1
17	198.7	3.02	4.8
18	200.1	2.05	-0.7
19	201.5	2.93	2.3
20	201.6	2.13	-1.6
21	202.3	2.26	8.2
22	206.1	2.17	-0.8
23	206.5	2.22	0.1
24	208.3	1.82	4.8
25	212	2.23	3.3
26	215.3	2.75	5.0
27	215.6	2.82	6.6
28	218.5	2.65	-1.0
29	218.6	5.53	0.9
30	220.3	2.49	6.5
31	225.3	2.5	10.1
32	227.4	2.57	0.4
33	227.6	2.42	-4.2
34	227.7	2.33	0.9
35	230.4	2.87	5.8
36	240.2	2.31	-0.6
37	241.6	2.95	4.5
38	246.7	2.4	4.8
39	288.6	2.6	1.1
40	300.6	3.93	6.6
41	315.6	3.29	1.6
42	338.8	8.61	-1.7
43	340	3.01	-2.4
44	359.9	3.31	2.0
45	368.4	3.8	2.8
46	373.1	3.77	5.0
47	373.9	6.87	2.1
48	381	4.18	1.5
49	387.3	3.64	5.4
50	408.9	3.9	2.4
51	455.6	4.45	-2.6
52	524.7	8.88	0.7
53	549.3	5.88	2.5
54	748.1	7.66	0.6

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2	844.4	9.48	3.9
3	1697.2	18.38	2.4
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6	611.5	8.65	3.0
7	603.6	5.42	-1.6
8	602	5.66	0.2
9	599.3	5.92	-1.9
10	597.3	6.11	1.5
11	593.8	5.33	0.8
12	591.4	6.77	0.6
13	610.1	9.85	-0.5
14	627.5	13.66	-3.8
15	600.7	4.96	1.0
16	588.1	4.96	1.9
17	593.2	5.15	1.2
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21	345.5	5.1	1.4
22	343.9	3.13	-0.6
23	343.6	3.27	-1.0
24	355.3	3.56	-3.0
25	339.1	3.61	-1.4
26	345.7	3.13	-1.5
27	334.7	3.81	-0.8
28	334.5	5.38	-3.6
29	331.7	7.23	1.1
30	342	2.85	-0.2
31	339.9	2.91	-0.7
32	335.8	2.95	-1.7
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X-Y Weighted Mean:
X = 0.28142±0.00033 2σ
Y = 0.039749±0.000032
X-Y error correlation = +0.673
MSWD = 1.18, Probability =

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PRB72	1.1555	0.0190	0.0500	0.0018	0.0082	0.0002	0.1731	0.0060
PRB57	2.1293	0.0350	0.0496	0.0015	0.0080	0.0001	0.1750	0.0051
PRB22	0.1512	0.0027	0.0503	0.0016	0.0086	0.0003	0.1786	0.0054
PRB90	0.4214	0.0071	0.0507	0.0018	0.0089	0.0002	0.1824	0.0062
PRB19	0.5837	0.0100	0.0489	0.0013	0.0084	0.0002	0.1769	0.0044
PRB5	0.7865	0.0160	0.0525	0.0025	0.0092	0.0004	0.1916	0.0085
PRB42	0.7710	0.0211	0.0494	0.0027	0.0079	0.0004	0.1820	0.0097
PRB80	0.6123	0.0100	0.0491	0.0011	0.0088	0.0002	0.1813	0.0039
PRB78	1.2360	0.0203	0.0530	0.0015	0.0087	0.0002	0.1965	0.0054
PRB103	0.6125	0.0106	0.0538	0.0026	0.0082	0.0003	0.1999	0.0093
PRB83	0.6243	0.0103	0.0483	0.0011	0.0088	0.0002	0.1799	0.0037
PRB31	0.6244	0.0129	0.0489	0.0020	0.0084	0.0003	0.1820	0.0072
PRB26	0.5240	0.0096	0.0528	0.0017	0.0086	0.0002	0.1985	0.0059
PRB87	0.6243	0.0104	0.0503	0.0015	0.0090	0.0002	0.1898	0.0055
PRB4	0.7588	0.0156	0.0512	0.0023	0.0093	0.0004	0.1942	0.0083
PRB39	0.8900	0.0216	0.0503	0.0025	0.0083	0.0004	0.1921	0.0092
PRB35	0.9537	0.0210	0.0505	0.0020	0.0085	0.0003	0.1930	0.0076
PRB71	0.6742	0.0111	0.0519	0.0014	0.0088	0.0002	0.1986	0.0052
PRB29	0.8749	0.0167	0.0533	0.0023	0.0085	0.0003	0.2040	0.0085
PRB2	0.4028	0.0085	0.0515	0.0024	0.0095	0.0004	0.1984	0.0087
PRB13	0.4246	0.0075	0.0516	0.0014	0.0090	0.0002	0.1988	0.0050
PRB40	0.7503	0.0186	0.0484	0.0024	0.0083	0.0004	0.1871	0.0091
PRB77	0.6807	0.0111	0.0503	0.0010	0.0088	0.0001	0.1953	0.0036
PRB37	0.1087	0.0026	0.0491	0.0021	0.0084	0.0004	0.1918	0.0079
PRB59	0.3126	0.0052	0.0495	0.0012	0.0090	0.0002	0.1937	0.0044
PRB36	0.4416	0.0101	0.0505	0.0021	0.0088	0.0004	0.1977	0.0079
PRB30	0.8557	0.0164	0.0492	0.0015	0.0088	0.0002	0.1929	0.0056
PRB92	0.3366	0.0056	0.0509	0.0014	0.0099	0.0002	0.1997	0.0053
PRB25	0.5354	0.0096	0.0495	0.0014	0.0090	0.0002	0.1947	0.0054
PRB55	0.7384	0.0277	0.0460	0.0036	0.0079	0.0006	0.1808	0.0141
PRB49	0.3659	0.0118	0.0547	0.0040	0.0084	0.0006	0.2156	0.0154
PRB48	0.2792	0.0088	0.0511	0.0033	0.0083	0.0005	0.2018	0.0129
PRB91	0.4262	0.0071	0.0502	0.0013	0.0099	0.0002	0.1986	0.0050
PRB43	0.5882	0.0164	0.0490	0.0027	0.0083	0.0004	0.1943	0.0106
PRB8	1.0195	0.0195	0.0489	0.0019	0.0097	0.0003	0.1939	0.0070
PRB24	0.4552	0.0082	0.0477	0.0018	0.0094	0.0003	0.1898	0.0071
PRB73	0.3299	0.0054	0.0513	0.0012	0.0092	0.0002	0.2044	0.0044
PRB110	0.8839	0.0152	0.0482	0.0013	0.0092	0.0002	0.1924	0.0052
PRB53	0.7311	0.0265	0.0500	0.0038	0.0081	0.0006	0.1994	0.0150
PRB50	0.4886	0.0158	0.0483	0.0031	0.0083	0.0005	0.1935	0.0122
PRB21	0.6680	0.0115	0.0516	0.0013	0.0094	0.0002	0.2073	0.0048
PRB65	0.8271	0.0136	0.0509	0.0014	0.0095	0.0002	0.2049	0.0054
PRB23	1.2473	0.0219	0.0531	0.0018	0.0091	0.0002	0.2136	0.0070
PRB18	0.5525	0.0095	0.0518	0.0018	0.0092	0.0002	0.2084	0.0069
PRB17	0.7132	0.0122	0.0547	0.0015	0.0097	0.0002	0.2203	0.0058
PRB45	0.4725	0.0139	0.0548	0.0041	0.0097	0.0006	0.2206	0.0160
PRB84	0.3867	0.0064	0.0487	0.0010	0.0093	0.0002	0.1964	0.0037
PRB79	0.5262	0.0086	0.0491	0.0009	0.0095	0.0001	0.1986	0.0034
PRB58	0.5913	0.0097	0.0510	0.0011	0.0095	0.0001	0.2072	0.0042
PRB70	0.5597	0.0092	0.0521	0.0016	0.0096	0.0002	0.2115	0.0061
PRB47	0.5005	0.0154	0.0477	0.0032	0.0088	0.0006	0.1948	0.0128

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2	PRB86	0.5701	0.0095	0.0505	0.0015	0.0096	0.0002	0.2076	0.0060
3	PRB3	0.4479	0.0094	0.0524	0.0023	0.0104	0.0005	0.2160	0.0091
4	PRB82	0.7329	0.0120	0.0496	0.0012	0.0098	0.0002	0.2057	0.0045
5	PRB81	0.7405	0.0122	0.0533	0.0013	0.0100	0.0002	0.2214	0.0053
6	PRB101	0.8361	0.0141	0.0499	0.0012	0.0100	0.0002	0.2076	0.0049
7	PRB102	0.2546	0.0044	0.0503	0.0015	0.0104	0.0003	0.2098	0.0061
8	PRB61	0.4714	0.0079	0.0544	0.0020	0.0101	0.0003	0.2272	0.0080
9	PRB14	0.2424	0.0043	0.0497	0.0015	0.0104	0.0003	0.2078	0.0059
10	PRB51	0.6696	0.0234	0.0465	0.0034	0.0085	0.0006	0.1945	0.0141
11	PRB46	0.4986	0.0150	0.0487	0.0029	0.0087	0.0005	0.2057	0.0121
12	PRB105	0.4605	0.0078	0.0495	0.0013	0.0100	0.0002	0.2091	0.0055
13	PRB109	0.4608	0.0080	0.0501	0.0018	0.0101	0.0003	0.2131	0.0073
14	PRB1	0.3950	0.0086	0.0528	0.0027	0.0107	0.0005	0.2276	0.0109
15	PRB89	0.4008	0.0067	0.0497	0.0014	0.0100	0.0002	0.2161	0.0059
16	PRB99	0.5015	0.0089	0.0514	0.0028	0.0113	0.0004	0.2250	0.0118
17	PRB106	0.6877	0.0117	0.0493	0.0014	0.0102	0.0003	0.2159	0.0057
18	PRB60	0.4029	0.0068	0.0547	0.0020	0.0103	0.0003	0.2405	0.0085
19	PRB108	0.2673	0.0046	0.0498	0.0013	0.0097	0.0003	0.2231	0.0057
20	PRB107	0.4130	0.0071	0.0503	0.0014	0.0109	0.0003	0.2258	0.0062
21	PRB56	0.4362	0.0072	0.0530	0.0010	0.0104	0.0002	0.2400	0.0043
22	PRB93	0.9444	0.0158	0.0522	0.0016	0.0111	0.0002	0.2407	0.0069
23	PRB98	0.9959	0.0170	0.0532	0.0023	0.0107	0.0003	0.2493	0.0105
24	PRB27	1.2138	0.0227	0.0541	0.0024	0.0104	0.0003	0.2539	0.0109
25	PRB10	0.4799	0.0090	0.0500	0.0019	0.0114	0.0004	0.2374	0.0086
26	PRB52	0.8075	0.0289	0.0511	0.0042	0.0096	0.0007	0.2427	0.0199
27	PRB97	1.2397	0.0209	0.0542	0.0018	0.0109	0.0003	0.2600	0.0085
28	PRB76	0.5244	0.0088	0.0564	0.0020	0.0128	0.0003	0.2767	0.0092
29	PRB74	0.8484	0.0141	0.0509	0.0019	0.0113	0.0002	0.2520	0.0092
30	PRB104	0.5237	0.0089	0.0484	0.0014	0.0119	0.0003	0.2397	0.0067
31	PRB68	0.7953	0.0131	0.0512	0.0016	0.0114	0.0002	0.2540	0.0075
32	PRB100	0.8421	0.0144	0.0541	0.0022	0.0120	0.0003	0.2713	0.0108
33	PRB85	0.5675	0.0094	0.0506	0.0012	0.0127	0.0002	0.2651	0.0061
34	PRB20	0.6194	0.0109	0.0536	0.0023	0.0116	0.0003	0.2822	0.0115
35	PRB64	0.8573	0.0141	0.0539	0.0015	0.0123	0.0002	0.2899	0.0075
36	PRB62	0.4843	0.0080	0.0527	0.0011	0.0137	0.0002	0.3328	0.0068
37	PRB9	0.4231	0.0082	0.0564	0.0024	0.0159	0.0006	0.3711	0.0152
38	PRB75	0.9673	0.0160	0.0537	0.0017	0.0160	0.0003	0.3716	0.0111
39	PRB54	0.7295	0.0271	0.0522	0.0043	0.0151	0.0011	0.3884	0.0316
40	PRB63	0.6364	0.0105	0.0517	0.0011	0.0167	0.0002	0.3864	0.0075
41	PRB67	0.7552	0.0124	0.0550	0.0013	0.0179	0.0003	0.4355	0.0093
42	PRB88	0.7582	0.0127	0.0557	0.0016	0.0190	0.0004	0.4520	0.0124
43	PRB69	0.8243	0.0137	0.0573	0.0016	0.0188	0.0003	0.4709	0.0129
44	PRB44	0.8507	0.0242	0.0554	0.0031	0.0168	0.0009	0.4562	0.0254
45	PRB94	0.6201	0.0106	0.0552	0.0018	0.0204	0.0005	0.4634	0.0145
46	PRB66	0.9359	0.0154	0.0579	0.0014	0.0199	0.0003	0.4948	0.0112
47	PRB16	0.3939	0.0068	0.0565	0.0014	0.0212	0.0005	0.5105	0.0118
48	PRB96	0.6416	0.0108	0.0543	0.0013	0.0236	0.0005	0.5481	0.0126
49	PRB41	0.6459	0.0174	0.0584	0.0030	0.0242	0.0012	0.6829	0.0348
50	PRB11	0.3084	0.0057	0.0605	0.0019	0.0305	0.0009	0.7416	0.0216
51	PRB28	0.6276	0.0118	0.0647	0.0018	0.0385	0.0010	1.0978	0.0284
52	PRB12	0.5093	0.0096	0.0712	0.0024	0.0442	0.0013	1.3733	0.0436
53	PRB7	0.6658	0.0131	0.1092	0.0037	0.0920	0.0032	4.5354	0.1448

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3	GJ1	0.0268	0.0007	0.0627	0.0028	0.0361	0.0021	0.8597	0.0370
4	GJ10	0.0272	0.0005	0.0587	0.0012	0.0344	0.0012	0.7947	0.0148
5	GJ11	0.0268	0.0005	0.0601	0.0013	0.0347	0.0013	0.8115	0.0167
6	GJ12	0.0272	0.0005	0.0584	0.0014	0.0324	0.0012	0.7848	0.0179
7	GJ2	0.0269	0.0006	0.0610	0.0017	0.0312	0.0014	0.8165	0.0213
8	GJ3	0.0268	0.0006	0.0603	0.0013	0.0307	0.0013	0.8026	0.0157
9	GJ4	0.0295	0.0007	0.0601	0.0019	0.0291	0.0014	0.7968	0.0243
10	GJ5	0.0299	0.0009	0.0598	0.0029	0.0319	0.0019	0.8181	0.0393
11	GJ6	0.0314	0.0011	0.0576	0.0039	0.0283	0.0022	0.8117	0.0545
12	GJ7	0.0275	0.0005	0.0607	0.0010	0.0329	0.0010	0.8175	0.0121
13	GJ8	0.0268	0.0005	0.0611	0.0010	0.0312	0.0011	0.8045	0.0126
14	GJ9	0.0280	0.0005	0.0607	0.0011	0.0316	0.0011	0.8067	0.0138
15	PL1	0.0865	0.0019	0.0543	0.0026	0.0179	0.0010	0.4118	0.0183
16	PL10	0.0892	0.0015	0.0529	0.0011	0.0166	0.0004	0.4000	0.0075
17	PL11	0.0892	0.0015	0.0527	0.0012	0.0164	0.0004	0.3977	0.0082
18	PL12	0.0890	0.0015	0.0518	0.0012	0.0174	0.0005	0.4043	0.0093
19	PL2	0.0862	0.0016	0.0524	0.0015	0.0169	0.0006	0.3900	0.0107
20	PL3	0.0881	0.0015	0.0524	0.0011	0.0165	0.0004	0.3985	0.0079
21	PL4	0.0900	0.0018	0.0526	0.0016	0.0152	0.0005	0.3866	0.0115
22	PL5	0.0952	0.0025	0.0509	0.0024	0.0144	0.0007	0.3737	0.0175
23	PL6	0.0981	0.0033	0.0538	0.0036	0.0155	0.0011	0.3912	0.0257
24	PL7	0.0938	0.0016	0.0531	0.0009	0.0159	0.0003	0.3995	0.0058
25	PL8	0.0882	0.0015	0.0528	0.0009	0.0164	0.0004	0.3943	0.0064
26	PL9	0.0899	0.0015	0.0521	0.0010	0.0167	0.0004	0.3842	0.0066
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4	0.0251	0.0003	0.3	194.6	81.75	164.4	3.03	162.1	5.22
5	0.0256	0.0003	0.4	175.3	69.01	161.6	2.17	163.7	4.38
6	0.0257	0.0003	0.3	209.7	70.96	173.3	5.95	166.9	4.62
7	0.0261	0.0003	0.3	226.6	78.88	179.7	4.81	170.1	5.29
8	0.0263	0.0003	0.4	142.3	59.74	169.7	3.32	165.4	3.75
9	0.0265	0.0004	0.3	307.7	102.68	185.6	7.75	178	7.28
10	0.0267	0.0005	0.3	165.4	121.69	158.5	8.17	169.7	8.33
11	0.0268	0.0003	0.4	150.8	52.2	177.3	2.98	169.2	3.34
12	0.0269	0.0003	0.4	328.5	63.38	174.9	2.96	182.2	4.55
13	0.0269	0.0003	0.4	328.5	63.38	174.9	2.96	182.2	4.55
14	0.0270	0.0004	0.3	362.2	104.26	164.6	5.69	185	7.9
15	0.0270	0.0003	0.5	115.9	50.25	176.6	2.96	167.9	3.16
16	0.0270	0.0004	0.3	140.5	93.07	169.9	5.82	169.7	6.19
17	0.0270	0.0004	0.3	140.5	93.07	169.9	5.82	169.7	6.19
18	0.0273	0.0003	0.4	320.4	69.32	172.6	4.41	183.8	5.03
19	0.0274	0.0003	0.4	207.6	68.8	180.7	3.91	176.5	4.72
20	0.0275	0.0004	0.3	251.3	99.39	186.5	7.93	180.2	7.03
21	0.0277	0.0005	0.3	208.3	109.54	167.8	7.41	178.5	7.83
22	0.0277	0.0004	0.4	218.9	90.9	170.5	6.28	179.2	6.46
23	0.0277	0.0003	0.4	281.5	61.77	177.7	3.21	184	4.43
24	0.0277	0.0003	0.4	281.5	61.77	177.7	3.21	184	4.43
25	0.0278	0.0004	0.3	339.6	94	171.4	5.16	188.5	7.14
26	0.0279	0.0004	0.3	264.3	102.11	190.7	8.88	183.7	7.36
27	0.0280	0.0003	0.4	266.9	60.23	180.3	4.37	184.1	4.26
28	0.0280	0.0005	0.3	117.9	112.38	167.6	7.62	174.1	7.74
29	0.0281	0.0003	0.5	209.1	44.91	177.3	2.67	181.1	3.05
30	0.0283	0.0004	0.4	153	96.31	169.6	7.73	178.1	6.76
31	0.0284	0.0003	0.4	170.9	54.49	180	3.48	179.8	3.7
32	0.0284	0.0004	0.4	218.1	92	176.7	7.01	183.1	6.69
33	0.0284	0.0004	0.4	218.1	92	176.7	7.01	183.1	6.69
34	0.0284	0.0003	0.4	158	68.63	177.3	4.69	179.1	4.73
35	0.0285	0.0003	0.4	234.8	62.2	198.8	4.68	184.9	4.45
36	0.0285	0.0003	0.4	171.7	66.73	180.6	4.18	180.6	4.62
37	0.0285	0.0007	0.3	0.1	175.07	158.4	11.76	168.8	12.1
38	0.0286	0.0007	0.3	400.1	154.39	169.8	11.75	198.2	12.89
39	0.0286	0.0006	0.3	246.7	141.87	167.4	10.7	186.6	10.88
40	0.0287	0.0003	0.4	204.8	59.65	198.5	4.26	183.9	4.21
41	0.0287	0.0003	0.4	204.8	59.65	198.5	4.26	183.9	4.21
42	0.0288	0.0005	0.3	148.7	124.36	166.3	8.85	180.3	8.98
43	0.0288	0.0004	0.3	140.6	86.44	194.7	6.63	179.9	5.95
44	0.0288	0.0003	0.3	84.4	89.58	188.2	5.37	176.4	6.01
45	0.0289	0.0003	0.4	255	51.22	184.7	3.46	188.8	3.68
46	0.0289	0.0003	0.4	109.5	64.57	185.7	4.54	178.6	4.41
47	0.0289	0.0007	0.3	195.7	166.1	162.9	11.69	184.6	12.68
48	0.0291	0.0006	0.3	112.7	143.24	167.3	10.51	179.6	10.38
49	0.0291	0.0006	0.3	112.7	143.24	167.3	10.51	179.6	10.38
50	0.0292	0.0003	0.4	266.7	54.97	188.5	3.54	191.3	4.02
51	0.0292	0.0003	0.4	238.2	62.3	190.1	3.1	189.3	4.54
52	0.0292	0.0003	0.3	332.7	74.95	183.1	3.86	196.6	5.81
53	0.0292	0.0003	0.3	274.9	77.09	184.8	4.61	192.2	5.81
54	0.0292	0.0003	0.4	399.1	59.85	194.6	3.99	202.1	4.8
55	0.0292	0.0003	0.4	399.1	59.85	194.6	3.99	202.1	4.8
56	0.0292	0.0006	0.3	403.3	157.41	194.2	12.54	202.4	13.33
57	0.0292	0.0003	0.5	134.6	46.76	186.5	3.2	182.1	3.16
58	0.0293	0.0003	0.5	153.5	42.24	190.9	2.85	183.9	2.85
59	0.0295	0.0003	0.5	240.4	48.48	191.5	2.76	191.2	3.49
60	0.0295	0.0003	0.4	287.6	66.92	193.7	3.92	194.8	5.09
	0.0296	0.0006	0.3	83.9	151.1	177.2	10.99	180.7	10.86

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2	0.0298	0.0003	0.4	217.7	68.23	193.1	4.24	191.5	5.05
3	0.0299	0.0004	0.3	301.8	98.32	208.5	9.28	198.5	7.61
4	0.0301	0.0003	0.4	177	53.32	196.1	3.33	189.9	3.82
5	0.0301	0.0003	0.4	343.2	55.76	200.6	3.55	203	4.39
6	0.0302	0.0003	0.4	190.5	56.2	201	4.28	191.6	4.11
7	0.0303	0.0003	0.4	209.1	68.77	209.3	6	193.4	5.15
8	0.0303	0.0003	0.3	385.9	78.93	202.6	5.19	207.9	6.58
9	0.0303	0.0003	0.4	181.5	68.06	209.4	5.86	191.7	4.96
10	0.0303	0.0003	0.4	181.5	68.06	209.4	5.86	191.7	4.96
11	0.0304	0.0007	0.3	22.5	165.56	171.7	11.88	180.5	11.94
12	0.0306	0.0006	0.3	133.9	134.27	175.8	10.25	189.9	10.21
13	0.0306	0.0003	0.4	171.8	62.05	200.3	4.82	192.8	4.58
14	0.0309	0.0004	0.3	197.4	80.22	203.9	6.02	196.1	6.12
15	0.0313	0.0005	0.3	318.4	110.22	215.7	10.74	208.2	9.04
16	0.0315	0.0003	0.4	180.2	64.63	201.3	4.66	198.6	4.9
17	0.0315	0.0003	0.4	180.2	64.63	201.3	4.66	198.6	4.9
18	0.0318	0.0005	0.3	258.1	118.68	226.4	8.61	206.1	9.74
19	0.0318	0.0003	0.4	160.5	62.9	205.3	4.92	198.4	4.76
20	0.0319	0.0004	0.3	400.1	78.88	207.9	5.79	218.9	6.92
21	0.0325	0.0004	0.4	185.1	60.86	195	5.28	204.5	4.75
22	0.0326	0.0004	0.4	208.9	65	218.8	5.66	206.7	5.16
23	0.0326	0.0004	0.4	208.9	65	218.8	5.66	206.7	5.16
24	0.0328	0.0003	0.5	327.6	42.97	208.2	2.99	218.4	3.51
25	0.0334	0.0004	0.4	293.6	66.29	223.3	4.62	219	5.62
26	0.0340	0.0004	0.3	338.2	95.19	214.1	5.74	226	8.54
27	0.0340	0.0005	0.3	376.5	96.34	209.4	5.79	229.8	8.84
28	0.0345	0.0004	0.3	193.3	85.97	229	7.75	216.3	7.08
29	0.0345	0.0009	0.3	243	180.06	194	14.23	220.6	16.28
30	0.0348	0.0004	0.4	380.7	74.22	218.8	4.93	234.6	6.85
31	0.0348	0.0004	0.4	380.7	74.22	218.8	4.93	234.6	6.85
32	0.0356	0.0004	0.3	466.9	74.87	256.8	6.14	248	7.33
33	0.0359	0.0004	0.3	235.4	84.64	226.3	4.89	228.2	7.44
34	0.0359	0.0004	0.4	117.3	67.28	239.1	5.84	218.1	5.51
35	0.0360	0.0004	0.4	250.5	69.29	228.9	4.22	229.8	6.08
36	0.0364	0.0005	0.3	373.4	89.46	241	6.52	243.8	8.65
37	0.0380	0.0004	0.4	224	54.95	254.2	4.68	238.7	4.89
38	0.0382	0.0005	0.3	354	92.51	233.7	6.69	252.4	9.13
39	0.0390	0.0004	0.4	365.3	59.81	247.4	4.01	258.5	5.88
40	0.0390	0.0004	0.4	365.3	59.81	247.4	4.01	258.5	5.88
41	0.0458	0.0004	0.4	315.5	48.57	275.5	4.41	291.7	5.18
42	0.0477	0.0006	0.3	467.5	92.66	319.6	12.24	320.5	11.27
43	0.0502	0.0005	0.4	357.2	68.49	321.3	5.88	320.8	8.2
44	0.0540	0.0014	0.3	295.4	176	303.7	22.73	333.2	23.14
45	0.0542	0.0005	0.5	272.9	46.48	335.6	4.75	331.7	5.45
46	0.0574	0.0005	0.4	411.7	49.16	359	5.46	367.1	6.59
47	0.0574	0.0005	0.4	411.7	49.16	359	5.46	367.1	6.59
48	0.0588	0.0006	0.4	441.2	62.13	379.7	7.79	378.7	8.65
49	0.0596	0.0006	0.4	501.8	62.44	376.6	6.77	391.8	8.92
50	0.0597	0.0011	0.3	429.1	121.26	336.3	18.15	381.6	17.71
51	0.0609	0.0007	0.4	419.6	70.3	407.8	9.75	386.6	10.04
52	0.0619	0.0006	0.4	526.7	51.82	397.7	5.99	408.2	7.6
53	0.0655	0.0007	0.4	472.7	53.72	423.9	9.06	418.8	7.92
54	0.0732	0.0007	0.4	381.7	52.95	472.2	9.69	443.7	8.24
55	0.0732	0.0007	0.4	381.7	52.95	472.2	9.69	443.7	8.24
56	0.0848	0.0015	0.3	545.4	109.35	484.1	24.21	528.5	21.02
57	0.0889	0.0010	0.4	620.5	64.74	607.3	17.73	563.3	12.59
58	0.1231	0.0013	0.4	764.1	56.12	764.4	18.61	752.3	13.76
59	0.1400	0.0017	0.4	962.2	66.41	874.3	25.63	877.6	18.65
60	0.3012	0.0037	0.4	1786.6	60.31	1779.3	60.01	1737.5	26.57

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3	0.0995	0.0015	0.3	697.7	93.82	715.9	41.4	629.9	20.19
4	0.0982	0.0009	0.5	556	42.77	682.7	23.75	593.8	8.39
5	0.0979	0.0010	0.5	607.6	46.3	689.7	25.09	603.3	9.38
6	0.0974	0.0010	0.5	545.4	51.05	643.5	24.15	588.2	10.16
7	0.0971	0.0010	0.4	639.2	58.49	620.9	27.46	606.1	11.93
8	0.0965	0.0009	0.5	615	44.7	611.6	25.07	598.3	8.87
9	0.0961	0.0012	0.4	608.4	66.88	579.9	27.38	595	13.73
10	0.0993	0.0017	0.4	595.2	102.89	633.7	37.52	607	21.94
11	0.1022	0.0023	0.3	514.7	141.86	564	42.88	603.4	30.56
12	0.0977	0.0008	0.6	627.9	34.72	654.2	19.97	606.7	6.75
13	0.0955	0.0008	0.6	641.1	36.36	620.5	20.99	599.3	7.1
14	0.0964	0.0009	0.5	627.3	39.17	629.1	22.17	600.6	7.74
15	0.0551	0.0008	0.3	382.2	101.63	357.6	18.78	350.2	13.17
16	0.0548	0.0005	0.5	325.8	44.71	333.6	7.81	341.7	5.45
17	0.0548	0.0005	0.5	314.5	48.72	328.7	8.33	340	5.97
18	0.0567	0.0006	0.4	274.1	53.9	349.5	9.63	344.8	6.71
19	0.0540	0.0006	0.4	301.8	64.82	339.3	11.25	334.4	7.83
20	0.0551	0.0005	0.5	304.8	47.47	329.8	8.42	340.6	5.73
21	0.0533	0.0006	0.4	311.3	68.37	304	10.54	331.9	8.39
22	0.0533	0.0009	0.4	235.4	106.51	289.7	14.68	322.4	12.96
23	0.0528	0.0012	0.3	361	142.09	310.7	20.95	335.2	18.78
24	0.0545	0.0005	0.6	334.8	36.05	318.8	5.65	341.3	4.24
25	0.0541	0.0005	0.5	319.8	39.37	329.2	6.9	337.5	4.64
26	0.0535	0.0005	0.5	288.9	41.83	334.1	7.2	330.1	4.86
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4	159.8	1.75	1.4
5	162.9	1.64	0.5
6	163.8	1.72	1.9
7	166	1.85	2.5
8	167	1.62	-1.0
9	168.4	2.38	5.7
10	170.1	3.03	-0.2
11	170.4	1.6	-0.7
12	171	1.73	6.5
13	171.4	2.34	7.9
14	171.6	1.6	-2.2
15	171.8	2.25	-1.2
16	173.3	1.89	6.1
17	174.1	1.83	1.4
18	174.9	2.44	3.0
19	176.2	2.79	1.3
20	176.2	2.42	1.7
21	176.4	1.74	4.3
22	176.6	2.28	6.7
23	176.6	2.56	3.4
24	177.7	1.8	3.6
25	178.3	2.87	-2.4
26	178.9	1.61	1.2
27	180	2.61	-1.1
28	180.4	1.67	-0.3
29	180.4	2.55	1.5
30	180.6	2	-0.8
31	180.9	1.85	2.2
32	181.2	1.88	-0.3
33	181.4	4.57	-6.9
34	181.8	4.07	9.0
35	181.9	3.8	2.6
36	182.2	1.83	0.9
37	182.7	3.32	-1.3
38	182.9	2.25	-1.6
39	183.3	2.12	-3.8
40	183.5	1.7	2.9
41	183.9	1.97	-2.9
42	183.9	4.48	0.4
43	184.8	3.91	-2.8
44	185.2	1.78	3.3
45	185.3	1.81	2.2
46	185.4	2.04	6.0
47	185.5	2.03	3.6
48	185.6	1.86	8.9
49	185.6	4.01	9.1
50	185.7	1.7	-1.9
51	186.2	1.65	-1.2
52	187.1	1.68	2.2
53	187.2	1.91	4.1
54	188.2	3.92	-4.0

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2	189.3	1.98	1.2
3	190	2.66	4.5
4	190.9	1.81	-0.5
5	191.1	1.86	6.2
6	191.6	1.93	0.0
7	192.1	2.08	0.7
8	192.4	2.15	8.1
9	192.5	2.01	-0.4
10	192.5	2.01	-0.4
11	192.8	4.52	-6.4
12	194.5	3.82	-2.4
13	194.5	2.03	-0.9
14	196	2.29	0.1
15	198.7	3.02	4.8
16	200.1	2.05	-0.7
17	201.5	2.93	2.3
18	201.5	2.93	2.3
19	201.6	2.13	-1.6
20	202.3	2.26	8.2
21	206.1	2.17	-0.8
22	206.5	2.22	0.1
23	208.3	1.82	4.8
24	212	2.23	3.3
25	215.3	2.75	5.0
26	215.6	2.82	6.6
27	215.6	2.82	6.6
28	218.5	2.65	-1.0
29	218.6	5.53	0.9
30	220.3	2.49	6.5
31	225.3	2.5	10.1
32	227.4	2.57	0.4
33	227.4	2.57	0.4
34	227.6	2.42	-4.2
35	227.7	2.33	0.9
36	230.4	2.87	5.8
37	240.2	2.31	-0.6
38	241.6	2.95	4.5
39	246.7	2.4	4.8
40	288.6	2.6	1.1
41	288.6	2.6	1.1
42	300.6	3.93	6.6
43	315.6	3.29	1.6
44	338.8	8.61	-1.7
45	340	3.01	-2.4
46	359.9	3.31	2.0
47	368.4	3.8	2.8
48	373.1	3.77	5.0
49	373.1	3.77	5.0
50	373.9	6.87	2.1
51	381	4.18	1.5
52	387.3	3.64	5.4
53	408.9	3.9	2.4
54	455.6	4.45	-2.6
55	524.7	8.88	0.7
56	549.3	5.88	2.5
57	549.3	5.88	2.5
58	748.1	7.66	0.6
59	844.4	9.48	3.9
60	1697.2	18.38	2.4

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3	611.5	8.65	3.0
4	603.6	5.42	-1.6
5	602	5.66	0.2
6	599.3	5.92	-1.9
7	597.3	6.11	1.5
8	593.8	5.33	0.8
9	591.4	6.77	0.6
10	610.1	9.85	-0.5
11	627.5	13.66	-3.8
12	600.7	4.96	1.0
13	588.1	4.96	1.9
14	593.2	5.15	1.2
15	345.5	5.1	1.4
16	343.9	3.13	-0.6
17	343.6	3.27	-1.0
18	355.3	3.56	-3.0
19	339.1	3.61	-1.4
20	345.7	3.13	-1.5
21	334.7	3.81	-0.8
22	334.5	5.38	-3.6
23	331.7	7.23	1.1
24	342	2.85	-0.2
25	339.9	2.91	-0.7
26	335.8	2.95	-1.7
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