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A missing link in the Peri-Gondwanan terrane collage: the Precambrian basement of the Moroccan Meseta and its lower Paleozoic cover

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1 **A missing link in the Peri-Gondwanan terrane collage: the Precambrian**
2 **basement of the Moroccan Meseta and its lower Paleozoic cover**

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Abstract

This article provides stratigraphic and geochronological data from a central part of Gondwana's northern margin – the Moroccan Meseta Domain. This region, located to the north of the Anti-Atlas area with extensive outcrops of Precambrian and lower Paleozoic rocks, has hitherto not received much attention with regard to its Precambrian geology. Detrital and volcanic zircon ages have been used to constrain sedimentary depositional ages and crustal affinities of sedimentary source rocks in stratigraphic key sections. Based on this, a four-step paleotectonic evolution of the Meseta Domain from the Ediacaran until the Early Ordovician is proposed. This evolution documents the transition from a terrestrial volcanic setting during the Ediacaran, to a short-lived carbonate platform setting during the early Cambrian. The latter then evolved into a rifted margin with deposition of thick siliciclastic successions in graben structures during the middle to late Cambrian. The detritus in these basins was of local origin and a contribution from a broader source area (encompassing parts of the West African Craton) can only be demonstrated for post-rifting i.e. laterally extensive sandstone bodies that seal the former graben. In a broader paleotectonic context, it is suggested that this Cambrian rifting is linked to the opening of the Rheic ocean, and that several peri-Gondwanan terranes (Meguma and Cadomia/Iberia) may have been close to the Meseta Domain before drifting, albeit some of them seem to have been constituted by a distinctly different basement.

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Key words: paleogeography – West African Craton – Peri-Gondwanan terrane – detrital zircons – Cambrian

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52 **Introduction**

53 Shortly after the acceptance of the plate tectonics theory by the majority of geoscientists all
54 over the world, the Canadian geologist Paul E. Schenk published a sweeping and thought-
55 provoking paper in the *Canadian Journal of Earth Sciences* on the application of new global
56 tectonics to the Precambrian and Paleozoic geological evolution of Northwest Africa and
57 Atlantic Canada (Schenk 1971). Schenk’s paper was based on Wilson’s (1966) proposal that
58 ocean basins may have opened and closed several times in Earth’s history along similar lines
59 and that the Atlantic Ocean might thus have had several precursors. Starting from the late
60 Paleozoic Bullard-Choubert fit (see Kornprobst 2017 for a justification of that term) of the
61 circum-Atlantic continents with North Africa (mainly Morocco) and Atlantic Canada
62 (Newfoundland, Nova Scotia) and the northeastern USA adjacent to each other, Schenk
63 suggested a high degree of tectonic mobility of small continental blocks (tectonic terranes
64 *avant la lettre*) over several ocean-spreading-and-closing (Wilson) cycles. The eventual
65 outcome of this prolonged history of spreading and collision was that “*Africa has*
66 *progressively lost increments of continental crust to North America.*” (Schenk 1971, p. 1218).
67 Interestingly, Schenk’s reasoning had already been partially anticipated by Choubert (1935)
68 who ascribed an “African” (i.e. Gondwanan) origin to parts of present-day northern America
69 (namely Florida, see Letsch 2017).

70 Even though Schenk’s approach was very schematic and geologically not particularly well
71 founded (at least as far as Africa was concerned), and consequently not well received by
72 geologists working in Morocco (Hollard and Schaer 1973), at least parts of his general
73 message have been confirmed by later work. Reworked basement and cover relics, which are
74 widely distributed over western Europe and eastern North America, preserve the traces of a
75 common or at least very similar geological history during the Neoproterozoic and the early

Cambrian (Murphy and Nance 1989, see Fig. 1). This history is generally linked to an elongated and long-lasting subduction zone at the periphery of West Gondwana (West African and Amazonian cratons), and the continental fragments which were later detached from this active margin are variously referred to as Avalonian-Cadomian or peri-Gondwanan terranes (e.g. Nance and Murphy 1994; Keppie et al. 2003; von Raumer et al. 2003; Linnemann et al. 2008, or Garfunkel 2015). In pronounced contrast to the quickly growing geochronologic database for many peri-Gondwanan terranes and the northern margin of the West African Craton (i.e. the likely place of origin of these terranes), a small but central part of the peri-Gondwanan collage – the Moroccan Meseta (Fig. 2) – has not received much attention from a geochronological point of view until today (Dostal et al. 2005, Pereira et al. 2015, Ouabid et al. 2017). This is despite the fact, that a rich regional geologic history of the area is available in the literature (see e.g. Gigout 1951, Michard 1976, Piqué 2001, Hoepffner et al. 2005, Michard et al. 2008, 2010 for regional monographs and summary papers). It is the primary aim of the present paper to discuss the late Precambrian and early Paleozoic history of this missing link to which we will refer to as the Meseta Domain. This discussion is based on the interpretation of stratigraphic key sections and detrital and volcanic U/Pb zircon ages. These are used for both constraining the depositional age of sedimentary successions and the crustal affinities of the rocks in the source areas providing the sedimentary detritus.

From a global paleogeographic perspective, the Meseta Domain is often viewed as the most external or peripheral part of Gondwana. It has supposedly *not* been detached as a peri-Gondwanan terrane (but see e.g. Feinberg et al. 1990, von Raumer et al. 2003, Burkhard et al. 2006, or Stampfli et al. 2013 for a different view, assuming a highly mobile Meseta Domain during parts of the Paleozoic) but was originally very close or even adjacent to these terranes. Accordingly, it is supposed to have experienced a similar Neoproterozoic and Cambrian geologic evolution (e.g. Linnemann et al. 2008, Waldron et al. 2009, Landing and

MacGabhann 2010, or Nance et al. 2012). On the other hand, from the Northwest African point of view, the Meseta Domain plays the role of a “northern continental block” for Neoproterozoic (“Pan-African”) plate reconstructions of the Anti-Atlas orogenic belt. In this context, it supposedly collided in late Cryogenian times with the northern margin of the West African Craton (Leblanc and Lancelot 1980) thereby closing an oceanic basin whose remains are preserved in the Bou Azzer ophiolite (Leblanc 1976). The second aim of the paper is to discuss the question whether the Meseta Domain represents a detached sliver of the West African Craton (thus exhibiting Cadomian isotopic characteristics), or rather a basement block (or blocks) of Avalonian affinity i.e. juvenile continental crust with mantle extraction and magmatic crystallization ages of about 1000 Ma (e.g. Nance et al. 2008). The latter has been advocated by Pouclet et al. (2007) but contested by Landing (1996, Landing and MacGabhann 2010) and Dostal et al. (2005). Better knowledge of the late Proterozoic and early Palaeozoic history of the Moroccan Meseta could furthermore shed new light on the question of the paleogeographic provenance of the Meguma terrane of Nova Scotia. Schenk (1997) has proposed tight stratigraphic connections between these two zones for Cambrian until Devonian times (see also Stampfli et al. 2013). The new geochronological and stratigraphic data presented in this article will allow to test proposed correlations among the Moroccan Meseta, the Anti-Atlas, Cadomia, Avalonia and Meguma.

Regional geological setting

The Meseta Domain is divided from the Anti-Atlas Domain by a composite fault zone – recently referred to as the South Meseta Fault Zone (SMFZ, Michard et al. 2010, Fig. 2) – which runs across the High Atlas Belt, and is itself a much younger (Mesozoic to Cenozoic) feature juxtaposed to an older geological structural fabric (see also Ouanaïmi et al. 2016). Nevertheless, the SMFZ approximately delineates the southern margin of a zone that experienced intense late Paleozoic (Variscan) tectonic deformation and metamorphism

coupled with abundant granitic intrusions (Mattauer et al. 1972, Hoepffner et al. 2005, Michard et al. 2010). Due to this deformation and metamorphism, the original pre-Variscan connections to the northern margin of the West African Craton (WAC), well preserved in the Anti-Atlas belt, have been obscured. There is some debate on the relative positions of these two tectonic provinces relative to each other during different periods of time. The continuity of a glacial depositional systems is well-documented for the Ordovician (Le Heron et al. 2007) and thus excludes any later continental-scale movements between the two domains (such as the ones proposed by von Raumer et al. 2003 or Stampfli et al. 2013). However, a maximum of some 200 km of lateral displacement has been suggested e.g. by Mattauer et al. (1972) but questioned by later workers on stratigraphic and structural grounds (Binot et al. 1986 or Bernardin et al. 1988). In any case, the situation is different for the Neoproterozoic and Cambrian. The Bou Azzer ophiolite of the Anti-Atlas (Leblanc 1976) and the relics of at least one intraoceanic arc (Blein et al. 2014, Triantafyllou et al. 2016) along the Anti-Atlas Major Fault (Fig. 2, the “Bou Azzer suture” on Fig. 1a), render it very plausible to assume at least a small marginal ocean basin between the WAC (encompassing also most of the Anti-Atlas) and the Meseta Domain (including the northern part of the Cenozoic High Atlas Domain) during parts of the Cryogenian (e.g. Soulaïmani et al. 2006, Bousquet et al. 2008). However, there is also increasing evidence that the basement of the Meseta Domain comprises ca. 2000 Ma basement of WAC affinity (Dostal et al. 2005, Pereira et al. 2015) and consequently, the existence of a major ocean basin during the Neoproterozoic seems unlikely. The situation might rather resemble an Alpine-type one with a narrow and rather short-lived oceanic basin between two essentially similar continental areas. During the early and middle Cambrian, both the Meseta and parts of the Anti-Atlas domains experienced strong rifting and crustal thinning that lead to sediment-filled graben structures (Bernardin et al. 1988, see Fig. 2). In the northernmost part of the Anti-Atlas Domain (the Ouzellagh Massif, being located in the present-day High Atlas), a serpentinized peridotite sliver smeared out along a younger

fault and ophicalcite-pebble bearing conglomerate units (Pouclet et al. 2007) might furthermore indicate strong crustal thinning and even mantle denudation (a hyper-extended rifted margin, see e.g. Masini et al. 2013). Alternatively, they could also mark the continuation of the Bou Azzer suture, otherwise covered by younger rocks, below the Mesozoic to Cenozoic High Atlas Belt (implying an alternative placing of this suture as the one suggested on Fig. 2 along the poorly understood Anti-Atlas Major Fault), or a combination of both explanations might apply best. However, there is no field evidence for any drifting between the Meseta Domain and the WAC during the early Paleozoic. On the other hand, two (admittedly not so well constrained) apparent polar wander paths for the Paleozoic of both the Meseta Domain and the northern margin of the WAC (including the Anti-Atlas) seem to indicate a latitudinal difference of some 30° between these domains during the early Paleozoic (Feinberg et al., 1990). However, the findings of Feinberg et al. (1990) were later contested by new paleomagnetic data from the Meseta Domain (Khattach et al. 1995), that suggest that the two domains had been attached to each other since at least the middle Cambrian.

Given the lack of good outcrops and the absence or sparseness of datable fossils in the few Precambrian outcrops of the Meseta Domain, the late Precambrian and Cambrian stratigraphy of the Anti-Atlas has traditionally been taken as a template to organize the scattered observations in the former area (e.g. Gigout 1951, Michard 1976). However, there is still not much geochronologic or paleontologic evidence available to corroborate these correlations (Baudin et al. 2003, El Houicha et al. 2002), whereas there is increasing evidence for the existence of a Paleoproterozoic basement beneath the Meseta Domain with WAC affinity (Dostal et al. 2005, Michard et al. 2010, Pereira et al. 2015).

The Meseta Domain is divided into the Western and the Eastern Meseta which are separated from each other by the Middle Atlas Belt (Fig. 2). For the present study, we have

concentrated our efforts on the Western Meseta because Precambrian rocks are lacking in the Eastern Meseta (but see Hoepffner et al. (2006) and Ouanaïmi et al. (2016) for some information on the early Paleozoic history of that area). The Western Meseta is divided into – from East to West – the Nappe Zone (with gravitational sedimentary nappes of Variscan age), the Central Zone, and the Coastal Block (Fig. 2). These zones have been affected to variable degrees by late Paleozoic (Variscan) deformation, metamorphism and felsic intrusions with the Coastal Block being the least affected. Interestingly, off-shore West Morocco, orthopyroxene-bearing granodiorites (charnokites) have been dredged from the continental rise (the Mazagan or El Jadida escarpment, Fig. 2), and have yielded whole rock and quartz/feldspar fraction K/Ar ages of 900 to 1000 Ma (Ruellan 1985). These ages, if they indeed reveal real crystallization ages, would stand in contrast to the basement of the WAC where such ages are absent, and hence could be taken as indication for basement relics of a different provenance (Laurussia or Avalonia?) offshore the Meseta Domain. Notably, Tahiri et al. (2010) suggested that the Sehoul Block just north of the Central Massif (Fig. 2) might represent a fragment of Avalonia that became attached to the Meseta during a Late Devonian to early Carboniferous collision following subduction of the Rheic ocean. In such a scenario, the Mazagan escarpment might represent the lateral continuation of the Sehoul Block. However, detrital zircon data from Cambrian sediments from the Sehoul Block do not support an Avalonian origin (Pérez-Caceres et al. 2017), and the different degrees of metamorphic overprint of both areas are further indications against such a correlation (Michard et al. 2010).

Basement outcrops and their immediate sedimentary cover in the Meseta Domain

There are only few locations in the Moroccan Meseta where basement can be safely attributed to the Precambrian. Biostratigraphically meaningful fossils are lacking except for some poorly preserved (and questionable) archaeocyathids mentioned by Morin (1962a). Hence, early Cambrian and late Neoproterozoic ages have been inferred for these basement

outliers and their immediate sedimentary cover through indirect arguments such as overlying strata of supposedly Cambro-Ordovician age and comparison with the well-known stratigraphy of the Anti-Atlas.

Central and Nappe zones

Precambrian outcrops in the Central Massif of the Central and Nappe zones (Fig. 2) occur as small basement inliers in the core of a large SW-NE trending anticlinorium of Variscan age – the Zaïan anticlinorium – in the SE corner of the Central Massif (e.g. Morin 1960, 1962d, Michard 1976, Hoepffner et al. 2005, Michard et al. 2010). The metamorphic overprint is weak (upper greenschist facies at the highest, Bouabdelli 1994) and tectonic deformation is concentrated within discrete zones. We have studied two sections in the southernmost tip of the Central Massif close to the border to the Middle Atlas (between the cities of Khenifra and Kasba Tadla, Figs. 4 and 5). For information on two other well-exposed sections nearby (Bou Acila and Goaida), displaying a similar stratigraphy, we refer to Morin (1960, 1962c,d), Michard (1976), Bouabdelli (1994), Michard et al.(2008). Recent petrographic, geochemical and geochronological investigations have allowed Ouabid et al. (2017) to distinguish three distinct granitic rocks suites in the Goaida area. LA-ICP-MS dating of zircons from all three suites yielded Ediacaran ages (625 ± 9 Ma, 600 ± 10 Ma, and 552 ± 10 Ma).

The Jbel Hadid section starts with greenish-grayish schists displaying intense crenulation with some intercalated fine-grained magmatic rocks (unit 1 on Fig. 4a). Microscopically, some of the schists are made up of a fine-grained matrix composed of quartz, feldspar, sericite, and white mica with abundant angular grains of plagioclase and some quartz (Fig. 5c). They may partly represent deformed metarhyolites. Without any tectonic contact visible in the field, these crenulated schists are followed by a unit comprising massive rhyolites, thick breccia layers, and some subordinate mafic flows (unit 2, Fig. 4, 5d). Contrary to the preceding unit, the rhyolites and sedimentary rocks of unit 2 display heterogeneous

deformation with almost undeformed domains separated by mylonitic bands of some 10 m thickness (see Bouabdelli 1994 for more details). Towards the top, the rhyolites decrease in abundance and get eventually completely replaced by breccias. The latter range from coarse to medium grained and contain pinkish-reddish rhyolite and feldspar/quartz fragments floating in a dark green quartz-feldspar-sericite matrix. Locally, the top of this unit is accompanied by lenses of quartz sandstone and intercalated deformed carbonate layers (unit 3, Fig. 4). The section is completed by a thick pile of grey shales with intercalations of greywackes, basic flows and some quartz sandstone units (unit 4). Morin (1962b-d) correlated the massive rhyolites and breccias of unit 2 with the “Précambrien III” (PIII) of the Anti-Atlas (i.e. the Ediacaran Ouarzazate Group or Supergroup of the modern nomenclature, e.g. Thomas et al. 2002) and the overlying shales with the middle Cambrian (“Paradoxides Shales”).

The second section is located some 15 km SW of the Jbel Hadid on a wide plain known as Bou Ibenrhar (Figs. 2, 4b). It resembles the former section but tectonic repetitions cannot be excluded based on local folding and faulting. We shall refer to the same lithostratigraphic units as for the preceding section without thereby implying strict stratigraphic correspondence. The base consists of phyllites and rhyolites (unit 2) that describe an upright antiform whose southern limb is not preserved, but instead occupied by a steep tectonic fault against crenulated phyllites of supposed Cambrian or Ordovician age (unit 5). The northern limb exhibits a profile with basic to intermediate flows, breccias (Fig. 3d), and phyllites at the base that are followed by a carbonate zone (unit 3) and again massive breccias. The carbonates are mostly finely layered or even laminated, totally recrystallized and displaying kink folding (Fig. 3a). However, there is a thin dolomite lens of some 50 cm thickness and restricted lateral extent (at least some 10 m) that preserves original textures and structures such as e.g. symmetric ripple marks (Fig. 3b, sample 15DL3). Microscopically, the rock is a grain- or packstone with abundant coated grains and carbonate intraclasts displaying a

variable degree of recrystallization (Fig. 6). Different kinds of coated grains can be discerned with sizes mostly ranging between 0.25 and 1 mm, even though some grains can be much larger (up to several mm). Most common are spherical to slightly elliptical grains with irregular, diffuse, and wrinkly laminations, which often form composite lumps of several individual grains with irregular shapes (Fig. 6a). With increasing degree of recrystallization, these grains pass to completely recrystallized elliptical grains composed of equant dolomite crystals. Ooids with regular concentric lamination are rare. A second carbonate zone of similarly deformed marbles, but without any preserved original textures, occurs above the thick breccia unit. It is not clear whether one has to assume a tectonic contact between the two units. The marble is covered by green metabasites with partly well-developed pillow structures (Fig. 3c). The section ends with a thick stack of grey sandy shales with intercalations of greywackes, some basic and intermediate lava flows, and very fine-grained laminites of questionable volcanic origin (sample 15DL5). In its upper part, this unit contains several quartz sandstone intercalations.

The western margin of the Central Zone provides even more restricted insights into the Precambrian basement than the Central Massif. Tiny basement outcrops occur in the central Rehamna Massif (Corsini et al. 1988, Baudin et al. 2003), where both tectonic deformation and polyphase, partly intrusion-related, metamorphism are stronger, with the latter reaching the amphibolite facies (Michard 1976, Hoepfner et al. 2005, Michard et al. 2008, 2010, Chopin et al. 2014). Even though the local Paleozoic stratigraphy is still controversial, its general outlines are fairly well established (Corsini et al. 1988, Baudin et al. 2003). In the Sidi-Ali region (Fig. 2), a strongly tectonized fine-grained granite or rhyolite forms the core of a small tectonic culmination – the Sidi Ali dome. It is covered by mica-rich metaconglomerates/metabreccias (containing – among others – pebbles of fine-grained, quartz-rich magmatic rocks with abundant tourmaline, Fig. 5e) and metarhyolites, which are

capped by often laminated and recrystallized sandy carbonates. They are in turn covered by a thick pile of grey shales with greywacke intercalations. The metarhyolite at the base has yielded an U/Pb zircon SIMS (SHRIMP) age of 593 Ma (Baudin et al. 2003).

Coastal Block

The westernmost part of the Meseta Domain consists of a gently deformed and low-grade metamorphic block west of the highly deformed Central Zone. A rhyolite from the eastern margin of the coastal block (Sebt Brikyine, PP on Fig. 2) has yielded a Paleoproterozoic U/Pb zircon SIMS (SHRIMP) age (2045.1 ± 6.6 Ma, Pereira et al. 2015). Coastal outcrops next to the city of El Jadida (Gigout 1951), display a basal rhyolite of supposedly Neoproterozoic age which is covered by massive, gently folded, dolomites with breccia and sandstone intercalations at the base. The dolomites contain in their upper part several m-scale lenses of ooid/oncoid packstones (Fig. 3f). The latter are composed of variably shaped (although mostly circular to slightly ellipsoid) coated grains ranging from simple ooids, over multiple and broken ooids/oncoids to completely recrystallized microspar grains all embedded in a microsparite to sparite matrix/cement (Fig. 6c,d). These grains range in size from less than 1 mm to 3 mm diameter with the majority ranging between 2 and 3 mm and all grains display a variable degree of recrystallization by randomly oriented dolomite crystals. This dolomite sequence is covered discordantly at El Jadida by Cretaceous carbonates. More towards the SE, in the nicely folded area around the water reservoir of Imfout, the supposed continuation of the El Jadida section is represented by at least 3000 m of greenish-grey schists with sandstone intercalations, which have yielded some trilobites (including *Paradoxides*, Gigout 1951). These “Paradoxides Shales” grade upwards gradually into a 50 to 100 m thick sandstone (partly feldspar-bearing) unit with two prominent, quartz-rich, marker horizons that can be traced all over the Western Meseta and are referred to as the “El Hank Quartzite” or the “El Hank Sandstone” (Michard 1976, Bernardin et al. 1988, Piqué 2001, Oukassou et al. 2017). It

is often massive, but does frequently display cross bedding and even herringbone cross stratification and hence points towards deposition in a shallow marine environment (André et al. 1987, Oukkassou et al. 2017). Viewed under the microscope, the sandstone is very densely packed, fine grained, and predominantly composed of rounded quartz grains with subordinate microcline and some zircon grains. The quartz grains frequently exhibit sutured contacts (Fig. 5f).

U/Pb age dating

Methods and samples

The objective of the U/Pb zircon age dating for the present study was twofold. Volcanic or volcanoclastic rocks have been sampled in order to obtain approximate depositional ages of their host rocks (see Supplementary Material 1 for sample localities). Clastic sedimentary rocks have been sampled for detrital zircon age distributions. They reflect to a certain degree the provenance of sedimentary detritus and the crustal affinity of the source areas. Furthermore, the youngest detrital zircons define the maximum depositional age of a given sample and can thus be used as older age brackets. Since individual zircon ages obtained by low-precision in-situ U/Pb age dating techniques can be misleading (Condon and Bowring 2011), we used the youngest graphical age peak of zircon age distributions as robust maximum depositional ages (Dickinson and Gehrels 2009).

Rock samples¹ of approximately 3 kg were fragmented using a high-voltage crushing device (Selfrag LabTM). Zircons have been separated from the crushed rocks by means of standard separation techniques and mounted in epoxy pellets. The internal structures of the zircons have been imaged by cathodoluminescence (CL) and back-scattered electron (BSE) methods using a TESCAN scanning electron microscope at the Department of Materials at

¹ Exact locations of sampling sites can be found in Supplementary Data 1. Supplementary data are available with the article through the journal web site at.....

ETH Zurich. Based on this information, suitable spots for U/Pb dating were chosen. U/Pb geochronology was conducted by laser ablation inductively coupled plasma mass spectrometry (LA-ICPMS) at the Institute of Geochemistry and Petrology, ETH Zurich. Measuring and data reduction followed the ETH standard lab procedures described in detail by e.g. Guillong et al. (2014). Analytical data are found in Supplementary Data 2. Only ages with a degree of concordance, defined as $(^{206}\text{Pb}/^{238}\text{U} \text{ age} / ^{207}\text{Pb}/^{235}\text{U} \text{ age}) * 100$, between 95% and 105%) have been used for detrital zircon age spectra and volcanic age calculations. In the case of volcanic rocks, supposed eruption ages have been calculated using the weighted mean of $^{206}\text{Pb}/^{238}\text{U}$ ages from certain zircon populations. Errors are reported to the 2σ uncertainty level.

Results

Sample 15DL1, taken from a rhyolite at the base of the Bou Iberhar succession (Fig. 4b) only contained few zircons. From a total of 4 dated crystals, 3 concordant ages could be obtained whose $^{206}\text{Pb}/^{238}\text{U}$ ages overlap within error yielding a weighted mean age of 569.6 ± 3.8 Ma (MSWD = 1, see Supplementary Data 2 for graphic representations of data). Given the small number of dated zircons and potential sources of inaccuracy and low precision inherent in in-situ U/Pb dating (Pb loss, moderate inheritance, even though CL-pictures did neither reveal inherited cores nor where ages discordant), one should not attach too much significance to this exact number; however, we think that it represents a general indication for the emplacement age of this rhyolite and hence, also for the depositional age of the lower part of the Bou Iberhar succession.

Sample 15DL6, an immature silty sandstone (greywacke) from the uppermost part of the Bou Iberhar section (Fig. 4b) yielded 151 concordant ages with an extremely narrow unimodal age distribution centering around 488 Ma (Fig. 9).

Sample 15DL9 represents a massive rhyolite from the central part of the Jbel Hadid section. From a total of 52 concordant ages (13 ages proved to be discordant) from 52 different grains (Fig. 8), 4 and 6 ages have been discarded from the beginning as being either too young as judged from the overall geologic situation (presumably due to Pb loss) or too old (presumably xenocrysts or detrital zircons taken up by the ascending magma or later by the pyroclastic cloud or flow producing the rhyolite, respectively). The remaining 42 ages display considerable scatter and no clear age populations can be discerned. Based on visual inspection, we divided the “central” ages into two populations, that resulted in two weighted mean $^{206}\text{Pb}/^{238}\text{U}$ ages (563.8 ± 3.6 Ma and 597.4 ± 2.7 Ma) with rather high MSWD values. Based on the better overlap of ages (reflected in a lower MSWD value) we interpret the second (older) value as being closer to the true crystallization age of this rhyolite and the younger age reflecting Pb loss. This inference is also borne out by other evidence as the zircons constituting the two age populations did neither differ in terms of crystal morphology nor CL characteristics. Finally, the age of 597.4 ± 2.7 Ma fits well with the recently published U/Pb zircon age of a granite from the nearby Goaida area (600 ± 10 Ma, Ouabid et al. 2017) and both rocks might have had a common magmatic source.

Sample 15DL11 was taken from the matrix of a tourmaline-bearing metaconglomerate from the Sidi Ali section (Fig. 5e). Somewhat similar to sample 15DL9, the few zircons producing concordant ages (13 in total, with 5 ages being discordant, see Supplementary Data 2 for graphic representations of data) display a diagonal age distribution on a weighted average plot with few overlapping ages ($^{206}\text{Pb}/^{238}\text{U}$ age range between ca. 548 and 624 Ma). Our data alone does not allow to judge whether or not this age scatter is real and hence of geological nature (as might be well the case for a clastic sediment), or simply due to analytical uncertainty (similar grain morphologies and CL characteristics seem to point more likely to the second possibility). However, granites ranging in age between 625 and 552 Ma have

recently been reported from the Mesetan Central Massif (Ouabid et al. 2017) and hence we propose these ages to be real and to indicate the existence of volcanic or magmatic rocks of that age in the source area of the tourmaline-bearing metaconglomerate. By implication, the latter's age would be younger than 548 ± 6.4 Ma, but given the low number of analyzed zircons we hesitate to attach too much weight to this maximum depositional age.

Sample 15DL12, a texturally mature quartz sandstone from the Imfout section yielded a bimodal detrital zircon age distribution curve (Fig. 9). Apart from a rather narrow Neoproterozoic peak (596 Ma), a smaller and broader Paleoproterozoic peak (2005 Ma) can be discerned. Three isolated ages range between 900 and 1100 Ma.

Discussion

Ediacaran and Cambrian evolution of the Meseta Domain

Combining our new geochronologic data with the lithostratigraphic framework of the Central and Western Meseta, we propose four evolutionary steps that are reflected by four informal lithostratigraphic groups (Figs. 7 and 10).

Above a poorly known basement with affinities to the northern WAC (Pereira et al. 2015), a widespread cover of continental clastic deposits with abundant interbedded silicic and subordinate intermediate to basic volcanic rocks (Group I) was deposited during the Ediacaran. Our U/Pb zircon ages from two rhyolites (597.4 ± 2.6 and 569.6 ± 3.8 Ma) are in general agreement with a similar rhyolite in the Rehamna (593 Ma, Baudin et al. 2003) and two recently dated granites in the Mesetan Central Massif (600 ± 10 Ma and 552 ± 10 Ma, Ouabid et al. 2017). Abrupt lateral facies and thickness variations, sedimentary facies (locally derived immature clastics), and the many rhyolite flows and ignimbrites are reasonably

explained by a continental setting with pronounced topography and substantial paleotectonic activity. A major time gap (ca. 1.5 Ga) between the Paleoproterozoic basement and the Ediacaran terrestrial clastic and volcanic rocks can only be proved directly in the Central Zone (Rehamna, Pereira et al. 2015). Elsewhere, the oldest exposed units are of Neoproterozoic age or they could hitherto not be dated. The maximum depositional age of the topmost part of Group I in the Rehamna area is poorly constrained by one zircon grain from the matrix of a metaconglomerate yielding an U/Pb age of 548 ± 6.4 Ma.

Group I grades progressively upwards into a carbonate-dominated unit (Group II) which can reach thicknesses of several hundred meters (Rehamna, Corsini et al. 1988). Due to tectonic deformation and recrystallization, the original fabric of these carbonates is mostly obliterated with the two exceptions in the El Jadida and Bou Ibenrhar sections (Fig. 6). The grain/packstone microfacies of these rocks point towards deposition in agitated, shallow water. The widespread distribution of Group II and the consistency of facies are best explained by assuming a shallow continental platform setting. The lack of any fossils at the localities studied hints towards a late Ediacaran or early Cambrian age which is in general agreement with the late Ediacaran maximum depositional age of the top of the underlying Group I.

The carbonates of Group II gradually develop into a thick clastic sequence dominated by grey sandy shales with interbedded greywackes and abundant basic flows (the latter often exhibiting pillow structures, Fig. 3c). This Group III, also referred to as “Schistes à Paradoxides” (Paradoxides Shales) in the older literature (e.g. Gigout 1951), displays extreme lateral thickness variations with the thickest parts being restricted to NNE-SSE trending graben structures (Fig. 2, Bernardin et al. 1988) and it contains signs of basic volcanism at many places (El Attari et al. 1997, Ouali et al. 2003, El Hadi et al. 2006). Hitherto considered as being mostly of middle Cambrian (Gigout 1951), or early late Cambrian age (based on

paleontologic evidence, Mergl et al. 1998), our new detrital zircon ages (Fig. 9a) rather suggests a youngest Cambrian or even Early Ordovician age (at least in the southeastern Central Massif). It should be mentioned here that this younger age assignment is in conflict with existing paleontologic data from the overlying El Hank quartz sandstone in the area of the Coastal Block pointing to a late Cambrian age for the latter. A possible solution to this contradiction would be to assume that the lower part of the El Hank sandstone in the Coastal Block area wedges out towards the east and is thus coeval with parts of the “Paradoxides Shales” in the Central Zone of the Meseta (as indicated on Fig. 10). Be it as it may, the extremely narrow zircon age distribution centering around 488 Ma without any Precambrian zircons has two important implications. First, there must have been a nearby source of intermediate to felsic, youngest Cambrian volcanic rocks that are currently unknown in the Moroccan Meseta Domain. This volcanism was likely related to the already well-known basic volcanism associated with Group III and we propose that also the latter might be rather of late than middle Cambrian age. Secondly, Group III sedimentary basins of the Mesetan Central Massif were shielded at that time from any sedimentary detritus derived from older units of the Meseta or from the Anti-Atlas area and the northern margin of the WAC. In accordance with previous authors (e.g. Piqué 2001, 2003) we interpret the diverse graben structures that received enormous amounts of locally derived detritus as the relics of a rifted continental margin with an ocean finally developing west (with reference to present-day geography) of the Meseta Domain. Shielding from sedimentary sources other than the immediate hinterland of the rift basins may have been achieved by uplifted rift shoulders, a phenomenon which is well-documented for e.g. the Mesozoic passive margins of Africa (Burke and Gunnell 2008).

A major paleogeographic shift is implied by the next higher Group IV, built of mature quartz sandstones (with subordinate arkose sandstones) that blanket wide areas of the Meseta with a remarkably constant thickness (the El Hank sandstone, e.g. André et al. 1987, Piqué

2001). The El Hank sandstone is part of a much wider distributed composite basin that developed during the Cambro-Ordovician all over present-day North Africa and the Middle East (Burke et al. 2003), due to thermal subsidence of previously rifted continental lithosphere. This inference is further corroborated by the detrital zircon age spectrum of Group IV sandstones from the western margin of the Central Zone (sample 15DL12, Fig. 9b). In strong contrast to the presumably only slightly older sample from the underlying rift-related greywackes (Fig. 9a) the age spectrum displays a bimodal age distribution with a major Ediacaran (596 Ma) and a minor Paleoproterozoic (ca. 2000 Ma) peak. This distribution pattern is in general agreement with those of many other contemporaneous mature sandstones from western North Africa and adjacent areas (e.g. Avigad et al. 2012, Meinhold et al. 2013) and may thus be regarded as an integrated age signal of an extended source area. This does likely not only encompass the Meseta Domain itself (where both age peaks could be identified in the Precambrian basement, Pereira et al. 2015 and this paper) but also the peripheral areas of the WAC (outcropping in the Anti-Atlas) where voluminous Neoproterozoic magmatism and volcanism is well documented (e.g. Hefferan et al. 2014). It is noteworthy that the age distribution of the El Hank sandstone is also very similar to that reported by Pérez-Caceres et al. (2017) from the middle (?) Cambrian sandstones from the Sehoul Block in the northern part of the Meseta Domain (Fig. 2).

The Meseta Domain and the Anti-Atlas

As pointed out previously, the Anti-Atlas area is a natural candidate for a comparison with the Meseta Domain. However, it should be noted that a direct comparison between the Meseta Domain and the Anti-Atlas is severely hampered by the very different quality of Precambrian and early Paleozoic outcrops in the two areas. Whereas in the former only tiny inliers allow a very restricted view of the whole story, rocks of that age form marvelous outcrops of wide extent in the latter. Despite these shortcomings, many striking similarities can be seen. The

Proterozoic basement (dominated by voluminous ca. 2000 Ma intrusions) is observed in both regions. However, the complicated pre-Ediacaran geological record of the Anti-Atlas (with extensive Proterozoic quartz sandstones, greywackes, ophiolites, or intraoceanic arc relics) has no present-day counterpart in the Meseta Domain. The widespread Ediacaran terrestrial clastic and volcanic rocks (our Group I), on the other hand, correlates very well both in terms of facies and age with the Ouarzazate Supergroup (Thomas et al. 2002, corresponding to PIII of older authors) of the Anti-Atlas (as already suspected by e.g. Morin 1962). Less straight forward is the correlation between the Meseta carbonate rocks (our Group II) and the carbonate-dominated late Neoproterozoic to early Cambrian Taroudant and Tata Groups of the Anti-Atlas (e.g. Geyer and Landing 1995, Alvaro et al. 2014). The classically evoked correlation with the Adoudou Formation (the base of the Taroudant Group) would explain the lack of fossils in our Group II, but the sedimentary facies of the two are quite different. Grainstones of the type encountered at El Jadida and Bou Ibenrhar are lacking in the Adoudou dolomites and the stromatolites so abundant in the latter seem to be missing in the Meseta Domain. In the Anti-Atlas, similar grainstones only occur in the upper part of the early Cambrian (Igoudine and Amouslek formations) together with first larger shelly fossils (trilobites and archaeocyathids). Despite the lack of the latter in the Meseta (with the exception of the Jebilet in its southern part, see e.g. Michard 1976), we tentatively assume a late early Cambrian age for our Group II (see also El Houicha et al. 2002). The overlying sandy shales with greywackes (our Group III) have traditionally been correlated with the trilobite-rich “Schistes à Paradoxides” of the Anti-Atlas (the Jbel Wawrmast Formation of Geyer and Landing 1995). Based on our new detrital zircon age dating with a narrow age peak around 488 Ma (i.e. youngest Cambrian) we discard this correlation at least for this parts of Group III which has been looked at for the present study. The Wawrmast Formation, on the other hand, which has been ascribed an early Tissafinian age (middle Cambrian, around 511 Ma according to Landing et al. 1998) based on fossils, contains K-bentonites and mafic flows

in the High Atlas and parts of the Anti-Atlas (Geyer and Landing 1995) that have so far not been dated radiometrically. The capping sandstones constituting our Group IV (El Hank Sandstone) can feasibly be correlated with the arenitic upper Cambrian Tabanite Group (Geyer and Landing 1995) of the Anti-Atlas, that exhibits similar, though not identical, detrital zircon age distribution patterns (Avigad et al. 2012). The Tabanite Group in the eastern Anti-Atlas area contains and is covered by basic to intermediate volcanics (Baidder et al. 2008), which could potentially be the expression of the same magmatic activity as the one recorded in the Meseta Domain. Finally, the occurrence of Early Ordovician red-beds, filling graben structures, in the northernmost Anti-Atlas Domain (Ouanaimi et al. 2016) deserves attention. Given our new age data, a temporal correlation between these red beds and the upper part of the “Schistes à Paradoxides” of the Central Massif seems not unreasonable.

In terms of paleotectonic considerations, the foregoing discussion can be summarized as follows. Both the Meseta Domain and the Anti-Atlas include a Paleoproterozoic basement with strong affinities to the WAC. The Meseta Domain and Anti-Atlas records appear different for the Cryogenian because the Meseta does not contain the lithologies and deformations evident in the Anti-Atlas for this time period. However, both records preserve evidence for a tectonically active intracontinental setting with abundant, mostly acidic, magmatic activity. The Meseta Domain and Anti-Atlas document a similar Cambrian history with large-scale rifting which is also, albeit not so prominently, seen in the Anti-Atlas (Piqué 2001, El Archi et al. 2004). These interpretations are consistent with recent paleotectonic models, which assume collision between the WAC's northern margin (Anti-Atlas), an intra-oceanic arc and finally a northern continental block (the Meseta) during the late Cryogenian with subsequent post-collisional intra-continental rifting and/or strike-slip deformation (e.g. Hefferan et al. 2014).

The Meseta Domain within the Peri-Gondwanan context

Schenk (1971) proposed that the Meseta Domain had great lateral mobility during the early Paleozoic (see also Feinberg et al. 1990, von Raumer et al. 2003, Burkhard et al. 2006, or Stampfli et al. 2013). Despite the fact that a one-to-one correlation between the Anti-Atlas and the Meseta Domain is not always possible (which is not surprising if one takes into consideration the lateral distance between the two areas and the facies changes observed within the two units), the general similarities of their late Neoproterozoic and Cambrian geologic histories is striking but explainable by assuming a Cryogeneian collision between the two blocks (see above). The lack of pre-Ediacaran marine strata in the Meseta Domain might be rationalized by hypothesizing that the Meseta Domain was in an upper plate position. However, a correlation, or even an identification between the Meseta Domain and the Avalonian terrane (as e.g. suggested by Pouclet et al. 2007, Gasquet et al. 2008) seems difficult for several reasons:

- *Sedimentary facies.* Whereas Avalonia's Neoproterozoic to early Paleozoic record is practically devoid of any shallow-water carbonates (Landing 1996), Cambrian carbonates (partly still preserving grainstone facies) are a common feature of the Moroccan Meseta. Furthermore, contrary to the Avalonian terrane (e.g. Keppie et al. 1991, Landing 1996, Murphy et al. 2013), no Ediacaran or older marine sedimentary rocks (rich in volcanic detritus) have yet been identified in the Meseta Domain.
- *No Neoproterozoic volcanic arc.* The Meseta Domain does not contain any direct or indirect (as e.g. detrital zircons) evidence for the development of an oceanic or a continental arc during the Cryogenian or the Ediacaran (unless one would interpret our Group I as the expression of Ediacaran arc magmatism in an Andean-type setting, as it has indeed been proposed by Tahiri et al. (2010) for the northern Meseta, or Walsh et al. (2012) for the similar Ouarzazate Supergroup of the Anti-

Atlas). This is in contrast to the Avalonian Terrane, where volcanic arc volcanism and arc-related sedimentation is well-documented (e.g. Murphy et al. 2013).

- *Basement*. Whereas for Avalonia a juvenile ca. 1000 Ma basement is well-established (Nance et al. 2002), no basement relics of that age have so far been found in the Meseta Domain with the exception of the questionable occurrence in the offshore Mazagan escarpment (see Fig. 2) whose direct link to the Meseta is not well-established.
- *Detrital zircons*. Our detrital zircon age data display a prominent lack of Mesoproterozoic ages (1200 to 1700 Ma). This feature has been identified by Garfunkel (2015) as being quite typical for sedimentary rocks from Cadomia-derived blocks but not for Avalonia-derived blocks.

Hence, a correlation between the Meseta Domain and Avalonia has many difficulties (see also Khattach et al. 1995 for paleomagnetic arguments) and also a correlation with Cadomia (see e.g. Fig. 10) cannot be achieved in a straight-forward manner due to different sedimentary facies and the absence of any arc-related rocks in the Meseta (even though both terranes display similar basement and detrital zircon ages). The terrane configuration suggested in Fig. 1 can principally account for these differences, because both Cadomia and Avalonia are in a more proximal position with regard to the suggested late Neoproterozoic subduction zone and arc magmatism may not have reached as far as to the Meseta Domain (schematically depicted in Fig. 10a).

However, whereas these differences mainly center on the Neoproterozoic and early Cambrian development, there is some agreement between the geological evolution of the Meseta Domain, the Meguma terrane of Nova Scotia, and certain supposedly Gondwana-derived fragments in Western Europe during the later Cambrian and Early Ordovician. Starting with Meguma, both areas (Meguma and Meseta Domain) document late Cambrian

573 rifting with thick siliciclastic graben fills and locally derived detrital zircons (Keppie et al.
574 1991, Schenk 1996). Published detrital zircon records from Meguma (Waldron et al. 2009)
575 resemble our new data (Fig. 9) in several respects: (i) a Mesoproterozoic gap or at least a
576 rarity of ages, (ii) important Ediacaran peaks, (iii) few Cryogenian ages, and (iv) a ca. 2000
577 Ma contribution (not in all samples). However, the important, albeit, according to present
578 knowledge, geographically restricted, late Cambrian contribution (488 Ma) does not exist in
579 Meguma. Thus it seems rather likely to assume a certain proximity between the Meguma
580 terrane and the Meseta Domain, at least during the late Cambrian and Early Ordovician (as
581 already suspected by Schenk 1971).

582 Seen from a broader paleotectonic perspective, this common Meguma and Meseta history
583 fits well with the opening of the Rheic ocean in the late Cambrian and Early Ordovician
584 (Nance et al. 2012) and perhaps the Meseta Domain, and the Meguma terrane tell the same
585 story albeit from the two different sides of the evolving Rheic ocean (see also Marzoli et al.
586 2017). Such a proximity of the Meseta Domain and Meguma is also suggested by the plate
587 reconstruction of von Raumer et al. (2003). However, given the supposed close connections
588 between Meguma and Avalonia during the entire Paleozoic (Murphy et al. 2004), such a
589 conjecture creates new difficulties for the early Paleozoic position of Avalonia since Landing
590 (1996, see also Landing and MacGabhann 2010) has provided convincing evidence for an
591 isolated position of the latter terrane at the end of the Ediacaran. It is beyond the scope of the
592 present paper to discuss these matters further, but we suggest that the Meseta Domain might
593 provide a missing link between Gondwana (the West African Craton) and Meguma, which
594 would strengthen the link between the latter two domains (advocated by Schenk 1971, 1996).
595 With regard to European basement fragments of supposed Gondwana-origin, we point out that
596 late Cambrian to Early Ordovician felsic magmatism (hitherto unknown from Morocco but
597 suggested by zircon ages from our sample 15DL6, Fig. 9a) is a well-known feature in several

areas of Cadomian and Iberian origin. Striking examples are provided by the pre-Mesozoic basement of the Alps (von Raumer et al. 2013), or the Tras-os-Montes Zone of central and NW Iberia (Talavera et al. 2013). In analogy with Meguma, this coincidence in late Cambrian/Early Ordovician magmatism could be explained by assuming that both Cadomia and Iberia were close to the Meseta Domain at that time and later detached from this part of Gondwana's margin as a consequence of the opening of the Rheic ocean.

Conclusions

- The Moroccan Meseta Domain shares many similarities with the much better known Anti-Atlas area with regard to basement (2000 Ma) and post-Cryogenian geologic development implying that the two areas have been closely together ever since at least the early Ediacaran.
- Differences with the Anti-Atlas area with regard to the Cryogenian geological evolution can be explained by invoking an intervening oceanic basin developing during the Cryogenian with subsequent closure and collision between the two blocks. This ocean shielded the Meseta Domain from receiving abundant sandy detritus from the WAC prior to the dawn of the Phanerozoic, which explains the absence of massive and thick Proterozoic quartz sandstone bodies that are typical of the Anti-Atlas area.
- Correlations between the Meseta Domain and several peri-Gondwanan terranes (Avalonia, Cadomia) are difficult, due to different sedimentary facies and the lack of convincing evidence for a Neoproterozoic volcanic arc in the Meseta Domain. This is probably due to a more distal position of the Meseta Domain with regard to the laterally very extended Neoproterozoic subduction zone invoked for many peri-

Gondwanan terranes. However, despite these differences a proximity among these different terranes does not seem implausible, and a possible Ediacaran setting is suggested in Fig. 10a.

- During the late Cambrian and Early Ordovician, the western Meseta Domain developed to a rifted margin presumably bordering the evolving Rheic ocean. Close stratigraphic resemblances and similar detrital zircon age distributions suggest that the Canadian Meguma terrane, Cadomia, and Iberia might have been in close proximity to the Meseta Domain during the late Cambrian albeit, on the other side of the evolving Rheic ocean and comprising partly different basement. The geology of the Meseta Domain, however, does not allow us to conclude whether or not this proximity was exclusively an early Paleozoic feature (caused e.g. by a collision between Cadomia/Meguma and the Meseta) or was already established during the Neoproterozoic.

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Figure captions:

Figure 1. a: A possible distribution of peri-Gondwanan terranes during the latest Precambrian with the position of the Moroccan Meseta indicated (redrawn and modified after Nance et al. 2002). RO: trace of the future opening of the Rheic Ocean. b: Peri-Gondwanan terranes and the Meseta Domain (black) on a late Paleozoic (Bullard-fit) continental reconstruction (redrawn and modified after Nance and Murphy 1994). AC: Amazonian Craton, SFC: Sao Francisco Craton, WAC: West African Craton, Ch: Chortis Block, Ox: Oaxaquia, Y: Yucatan, F: Florida.

Figure 2. Geological overview map of the Moroccan Meseta Domain and the Anti-Atlas Belt. Redrawn and simplified/modified after Michard et al. (2010) and Pereira et al. (2015). The Mid-Cambrian Meseta graben zones are schematically drawn after Bernardin et al. (1988). Post-Paleozoic areas are left blank. Localities studied for the present paper are indicated by asterisks.

Figure 3. Field pictures (for locations see Fig. 2). 3a: deformed and recrystallized carbonates (marble) from Bou Ibenrhar; 3b: carbonate grainstone with symmetric ripple marks (Bou Ibenrhar, 15DL4; for thin section pictures see Figs. 6a,b); 3c: pillow metabasalts (Bou Ibenrhar); 3d: breccia (Bou Ibenrhar: 15DL4); 3e: rhyolite from Jbel Hadid (15DL8); 3f: ooid grainstone at El Jadida (view on bedding plane; for thin section pictures see Figs. 6c,d).

Figure 4. Schematic geological sections across the Jbel Hadid and the Bou Ibenrhar plane in the southeast corner of the Central Massif of the Moroccan Meseta (for location see Fig. 2). Sample locations are indicated. Drawn after own observations with some additional information from Morin (1962b). Informal formations 1 to 5 have been defined and color-

coded on both cross sections. These correlations are based purely on lithologic comparisons.

Figure 5. Selected thin section photographs from volcanic and clastic rocks from the Meseta Domain (all pictures taken under crossed nicols). 5a: Almost undeformed rhyolite from Bou Ibenrhar (sample 15DL1). 5b: coarse grained greywacke from unit 4 (the “Paradoxides Shales”), Bou Ibenrhar (sample 15DL6). 5c: Deformed (?) metarhyolite (crenulated mica schist with isolated feldspar and quartz grains) from unit 1 of the Jbel Hadid section. 5d: volcanoclastic breccia from unit 2 of the Jbel Hadid section (sample 15DL10): rhyolite fragments and isolated quartz and feldspar grains in a fine grained quartz/feldspar/chlorite/sericite matrix. 5e: Matrix of deformed metaconglomerate from the Sidi Ali section: coarser- and finer grained quartz rich domains delineate former pebbles (the lower finer grained one containing abundant tourmaline). Note abundant metamorphic mica flakes (sample 15DL11). 5f: Fine grained quartz sandstone from the Im Fout locality (Upper Cambrian El Hank Sandstone).

Figure 6: a/b: Two thin section photographs (ordinary light) from a partially recrystallized but otherwise undeformed carbonate grainstone from the Central Massif (sample 15DL 4, Bou Ibenrhar, for locality see Fig. 2). c/d: thin section photographs of a partially recrystallized ooid-grainstone from El Jadida. See text for further explanations.

Figure 7: Stratigraphic correlation scheme of the areas studied in this paper. Sample localities, chronostratigraphic constraints, and the informal subdivision proposed in the text (Groups I to IV) are furthermore indicated.

Figure 8: U/Pb LA-ICP-MS ages from a rhyolite from Jbel Hadid (15DL9, see Fig. 4 for location). a: weighted average plot displaying individual ages from different zircon grains. See text for further explanation. b: Concordia diagram of the same ages displayed in a.

Figure 9: Relative probability (probability density) plots displaying the age distribution from detrital zircons from two sandstone samples from the Meseta Domain. See Fig. 2 for sample localities. a: sample 15DL6 (“Schistes à Paradoxides”) from the Central Massif; b: sample 15DL12 (El Hank Sandstone) from the Coastal Block.

Figure 10: Schematic paleogeographic sketch for the Ediacaran, displaying a possible scenario at Gondwana’s periphery (Fig. 10a) with the spatial relationships among the Anti-Atlas Domain, the Meseta Domain and Cadomia. Note that the Bou Azzer suture is only very schematically drawn and no suggestions as to its concrete geometry are implied (see Soulaïmani et al. 2006 for such a discussion). Synoptic stratigraphic charts for the latter two domains are shown in figures 10b (after Murphy et al. 2013) and 10c (summarizing data from the present study).

a

b

NE

SW

A) Jbel Hadid section

NNW

SSE

B) Bou Ibenrhar section

3: Carbonates with subordinate sandy intercalations (partly recrystallized and heavily deformed)

2: Breccias, sandstones, phyllites, rhyolites, and intermediate to mafic volcanic flows

1: Schists with crenulations and some volcanic intercalations

5: "Cambri-Ordovician" (sandstones, phyllites)

4: Shales with greywacke intercalations and basic flows ("Paradoxides Shales")

Quartz sandstone

★ Sample for geochronology (yielding zircons) with suggested age of emplacement (see text for further discussion)

☆ Sample for geochronology (yielding no zircons)

a

b

a) Ediacaran paleogeography, schematic & not to scale

Sample localities					
Sample #	Coordinates		Lithology	enough zircons for analysis (yes/no)	sample only for petrography
	N, W, respect.				
15DL1	32°45'43.5"	5°58'32.7"	greenish-reddish rhyolite	yes	
15DL2	32°45'43.5"	5°58'32.7"	fine grained volcanoclastics	no	
15DL3	32°46'0.8"	5°58'31.8"	oolitic carbonate		yes
15DL4	32°46'1.5"	5°58'39"	breccia	yes	
15DL5	32°46'49.9"	5°59'6.3"	laminated pelite ("cinerite")	no	
15DL6	32°47'0.7"	5°59'13.2"	immature sandstone (greywacke)	yes	
15DL7	32°48'39.8"	5°50'30.7"	green phyllite with crenulation (metarhyolite)	no	
15DL8	32°48'24.2"	5°50'23.9"	rhyolite	no	
15DL9	32°48'38.3"	5°50'8.8"	rhyolite	yes	
15DL10	32°48'47.7"	5°49'45.10"	green breccia	no	
15DL11	32°22'3.6"	7°58'13.42"	matrix from metaconglomerate	yes	
15DL12	32°44'43.2"	7°56'51.9"	quartz sandstone	yes	
J3C	33°15'47.9"	8°30'48.4"	oolithic carbonate		yes

15DL1, rhyolite, Group I (Ediacaran)

#	# Isotopic ratios (and 2σ errors)						Isotopic ages (and 2σ errors)						Disc.
	207Pb/ 235U	%±	206Pb/ 238U	%±	207Pb/ 206Pb	%±	207Pb/ 235U	±	206Pb/ 238U	±	207Pb/ 206Pb	±	%
1	0.766	0.017	0.09229	0.001	0.0595	0.0013	577.3	9.8	569	6	590	46	98.56
2	0.749	0.018	0.093	0.0013	0.0582	0.0012	566.9	11	574.3	8	528	47	101.31
3	0.736	0.017	0.09197	0.0011	0.0585	0.0013	560.7	10	567.1	6.6	540	46	101.14

15DL6, greywacke, Group III (upper Cambrian)

#	# Isotopic ratios (and 2σ errors)						Isotopic ages (and 2σ errors)						Disc.
	207Pb/ 235U	%±	206Pb/ 238U	%±	207Pb/ 206Pb	%±	207Pb/ 235U	±	206Pb/ 238U	±	207Pb/ 206Pb	±	%
4	0.6101	0.012	0.0741	0.0013	0.06001	0.0011	483.4	7.6	460.7	8	599	38	95.30
5	0.5842	0.012	0.07467	0.00094	0.05682	0.00087	466.9	7.6	464.2	5.6	481	34	99.42
6	0.5903	0.011	0.07548	0.00085	0.05697	0.00086	471.6	7	469.1	5.1	496	33	99.47
7	0.606	0.016	0.07596	0.00097	0.0575	0.0014	480.6	10	471.9	5.8	539	52	98.19
8	0.605	0.015	0.07645	0.0011	0.0574	0.0012	480.5	9.7	474.9	6.7	502	46	98.83
9	0.596	0.015	0.07647	0.001	0.0563	0.0013	475.4	9.6	475	6	461	54	99.92
10	0.614	0.015	0.0767	0.0012	0.0585	0.0011	487.2	9.3	476.5	7	545	42	97.80
11	0.6135	0.012	0.07674	0.0011	0.05774	0.00089	485.6	7.7	476.6	6.5	517	34	98.15
12	0.601	0.014	0.07678	0.00098	0.05652	0.001	477.3	8.7	476.8	5.9	477	41	99.90
13	0.609	0.015	0.07691	0.00095	0.0577	0.0012	483.6	9.3	477.6	5.7	517	45	98.76
14	0.611	0.013	0.07693	0.00096	0.05745	0.001	483.6	8.4	477.7	5.8	508	39	98.78
15	0.61	0.015	0.07681	0.00094	0.0582	0.0014	483.1	9.4	477.8	5.8	529	52	98.90
16	0.609	0.018	0.07695	0.0009	0.0572	0.0011	482.5	11	477.9	5.4	508	44	99.05
17	0.598	0.015	0.07708	0.00088	0.0564	0.0012	475.7	9.3	478.7	5.2	468	47	100.63

18	0.615	0.013	0.07709	0.0011	0.05789	0.00083	486.7	8	478.7	6.6	523	32	98.36
19	0.619	0.015	0.07722	0.0011	0.0578	0.0014	488.9	9.2	479.5	6.5	520	54	98.08
20	0.606	0.018	0.07739	0.0011	0.057	0.0017	481	11	480.5	6.6	495	62	99.90
21	0.62	0.015	0.07738	0.001	0.05773	0.00092	489.5	9.1	480.5	6	523	37	98.16
22	0.617	0.015	0.07742	0.00077	0.0571	0.0012	487.3	9.7	480.7	4.6	500	46	98.65
23	0.612	0.014	0.07746	0.00086	0.057	0.0011	484.5	8.5	480.9	5.2	502	41	99.26
24	0.627	0.016	0.07756	0.001	0.058	0.0015	493.7	10	481.5	6	543	54	97.53
25	0.62	0.015	0.07755	0.00089	0.0579	0.0013	489.6	9.7	481.5	5.3	543	51	98.35
26	0.623	0.016	0.07762	0.00092	0.0583	0.0013	491.4	10	481.9	5.5	533	50	98.07
27	0.614	0.016	0.07764	0.001	0.0578	0.0012	486	10	482	6	518	45	99.18
28	0.6189	0.012	0.07768	0.00084	0.05791	0.00098	489	7.4	482.2	5	534	37	98.61
29	0.611	0.016	0.07777	0.00091	0.057	0.0012	485.2	10	482.8	5.4	489	48	99.51
30	0.621	0.014	0.07779	0.00099	0.0578	0.0012	489.9	8.9	482.9	5.9	515	45	98.57
31	0.6212	0.013	0.0778	0.00072	0.05774	0.00095	491.3	7.7	482.9	4.3	515	36	98.29
32	0.616	0.018	0.0778	0.0011	0.0569	0.0013	487	12	482.9	6.4	497	51	99.16
33	0.627	0.016	0.07798	0.00094	0.0587	0.0013	493.6	10	484	5.6	549	46	98.06
34	0.624	0.016	0.07803	0.00097	0.0578	0.0013	492.1	9.7	484.3	5.8	523	49	98.41
35	0.624	0.015	0.07813	0.00084	0.0583	0.0014	493.2	9.9	484.9	5	532	52	98.32
36	0.62	0.013	0.07813	0.0009	0.0575	0.0011	491.1	8.7	485	5.4	518	45	98.76
37	0.616	0.014	0.07816	0.001	0.057	0.0012	487	8.9	485.1	6.1	483	47	99.61
38	0.624	0.017	0.07819	0.00093	0.058	0.0015	491.4	11	485.3	5.6	517	57	98.76
39	0.618	0.017	0.07822	0.001	0.057	0.0013	487.8	11	485.5	6	510	53	99.53
40	0.6166	0.012	0.07823	0.00083	0.05708	0.00087	487.6	7.4	485.6	5	493	34	99.59
41	0.624	0.017	0.07826	0.00086	0.0578	0.0013	492.9	10	485.7	5.1	524	50	98.54
42	0.615	0.013	0.07827	0.00095	0.057	0.0012	486.3	8.4	485.8	5.7	496	44	99.90
43	0.606	0.014	0.0783	0.00081	0.05625	0.001	480.6	8.8	486	4.8	462	41	101.12
44	0.6246	0.01	0.07835	0.00091	0.05791	0.00076	492.6	6.4	486.3	5.5	524	29	98.72
45	0.62	0.014	0.07839	0.00093	0.05758	0.00096	489.3	8.5	486.5	5.6	509	37	99.43
46	0.622	0.013	0.07839	0.00078	0.057	0.00097	490.9	8.3	486.5	4.7	497	38	99.10
47	0.62	0.014	0.0784	0.0012	0.05775	0.00098	489.2	8.7	486.5	7.3	515	37	99.45
48	0.623	0.014	0.07841	0.0009	0.0576	0.0012	492.3	9.3	486.6	5.4	515	47	98.84
49	0.613	0.015	0.07842	0.00097	0.057	0.0013	485.2	9.7	486.7	5.8	487	52	100.31
50	0.626	0.014	0.07844	0.00099	0.05734	0.001	493.2	8.5	486.8	5.9	502	39	98.70
51	0.636	0.017	0.0785	0.0014	0.0588	0.0014	501.5	11	486.9	8.2	554	50	97.09
52	0.636	0.017	0.0785	0.0012	0.0586	0.0015	499.5	10	487.1	6.9	561	50	97.52
53	0.632	0.013	0.07851	0.00097	0.058	0.0011	497.2	8.1	487.2	5.8	533	40	97.99
54	0.6238	0.012	0.07855	0.00088	0.05784	0.00086	492	7.6	487.5	5.2	525	31	99.09
55	0.619	0.017	0.0786	0.0012	0.0569	0.0016	489.2	11	487.8	7	481	62	99.71
56	0.623	0.019	0.07867	0.0011	0.0575	0.0017	491	12	488.1	6.5	502	67	99.41
57	0.624	0.014	0.07866	0.00099	0.0584	0.0011	492.1	8.9	488.1	5.9	537	43	99.19
58	0.616	0.013	0.07867	0.00083	0.05684	0.00098	487.3	8.2	488.2	5	480	38	100.18
59	0.616	0.013	0.07869	0.00082	0.0568	0.0011	486.8	8.5	488.3	4.9	483	45	100.31
60	0.63	0.016	0.07872	0.00097	0.0576	0.0013	495.3	9.9	488.5	5.8	528	50	98.63
61	0.607	0.018	0.0788	0.00086	0.0561	0.0015	481	11	488.9	5.1	449	57	101.64
62	0.62	0.014	0.0788	0.001	0.0576	0.0011	489.7	8.8	488.9	6.3	507	42	99.84
63	0.617	0.015	0.07886	0.00088	0.0563	0.0012	487.7	9.6	489.3	5.3	461	47	100.33
64	0.617	0.014	0.07889	0.00095	0.05686	0.001	487.8	8.5	489.5	5.7	480	40	100.35
65	0.6235	0.012	0.07891	0.00085	0.0573	0.00088	491.8	7.6	489.6	5.1	499	34	99.55
66	0.628	0.014	0.07891	0.00089	0.0581	0.0011	494.7	8.9	489.6	5.3	526	40	98.97
67	0.6261	0.012	0.07892	0.00085	0.05741	0.00084	493.4	7.7	489.7	5.1	504	32	99.25
68	0.629	0.015	0.07892	0.00095	0.0577	0.0013	494.8	9.5	489.7	5.6	516	49	98.97
69	0.618	0.015	0.07897	0.00093	0.057	0.0011	488	9.1	490	5.6	491	45	100.41
70	0.6292	0.012	0.079	0.0011	0.058	0.00098	495.5	7.4	490.1	6.4	527	38	98.91

71	0.6286	0.011	0.07901	0.00085	0.05732	0.00077	495.1	6.8	490.2	5.1	501	30	99.01
72	0.632	0.018	0.07914	0.00092	0.0578	0.0014	497	11	491	5.5	517	54	98.79
73	0.636	0.016	0.07919	0.00092	0.0581	0.0014	499.1	10	491.2	5.5	529	51	98.42
74	0.63	0.014	0.07919	0.00085	0.0575	0.0011	495.7	8.6	491.2	5.1	516	42	99.09
75	0.632	0.014	0.07922	0.00082	0.0578	0.0011	496.8	8.5	491.4	4.9	529	41	98.91
76	0.624	0.013	0.07923	0.001	0.05726	0.00079	492.2	8.3	491.5	6	502	31	99.86
77	0.6228	0.012	0.07931	0.00083	0.05701	0.00092	491.4	7.8	492	4.9	487	36	100.12
78	0.627	0.016	0.07937	0.00083	0.0579	0.0013	496.2	10	492.4	5	522	48	99.23
79	0.6332	0.012	0.0794	0.00085	0.0575	0.00087	497.8	7.7	492.5	5.1	507	33	98.94
80	0.618	0.013	0.07939	0.0009	0.0564	0.00097	488	8.1	492.5	5.4	468	40	100.92
81	0.63	0.014	0.0793	0.00094	0.0579	0.0013	495.6	8.9	492.8	5.9	524	47	99.44
82	0.641	0.016	0.07948	0.00086	0.059	0.0013	503	9.8	493	5.1	571	46	98.01
83	0.638	0.016	0.07947	0.00099	0.05831	0.001	502.3	9.3	493	5.9	543	39	98.15
84	0.629	0.018	0.07949	0.0011	0.0571	0.0013	494.7	11	493.1	6.4	492	51	99.68
85	0.6344	0.013	0.07949	0.00096	0.05831	0.00082	498.7	7.8	493.1	5.7	545	32	98.88
86	0.627	0.015	0.07949	0.00095	0.0572	0.0011	493.7	9.6	493.1	5.7	516	41	99.88
87	0.6205	0.013	0.07956	0.00085	0.05648	0.00094	489.9	7.8	493.5	5.1	466	36	100.73
88	0.619	0.015	0.07958	0.00077	0.0566	0.0012	488.8	9.3	493.6	4.6	467	46	100.98
89	0.639	0.014	0.07961	0.00099	0.05828	0.001	501.5	8.7	493.8	5.9	537	39	98.46
90	0.629	0.012	0.07963	0.00082	0.05688	0.00089	495.3	7.5	493.9	4.9	492	34	99.72
91	0.623	0.014	0.07969	0.0011	0.05689	0.00089	491.6	8.5	494.2	6.3	483	35	100.53
92	0.649	0.016	0.07975	0.0011	0.0585	0.0013	507.7	9.7	494.6	6.3	543	49	97.42
93	0.6278	0.012	0.07984	0.00093	0.05769	0.00087	496.8	8.5	495.1	5.5	514	33	99.66
94	0.652	0.021	0.07966	0.0011	0.0595	0.0016	509	13	495.5	7.1	577	58	97.35
95	0.637	0.014	0.0799	0.0009	0.0578	0.0011	500.3	8.8	495.5	5.4	526	41	99.04
96	0.615	0.015	0.0798	0.00092	0.0556	0.0013	486.3	9.4	495.6	5.7	435	54	101.91
97	0.628	0.014	0.07995	0.00076	0.0572	0.0012	494.3	8.7	495.8	4.5	490	46	100.30
98	0.644	0.016	0.07998	0.00088	0.0584	0.0012	505.9	9.5	496	5.3	539	45	98.04
99	0.6251	0.012	0.08002	0.00084	0.05678	0.0009	492.8	7.8	496.2	5	483	36	100.69
100	0.6242	0.012	0.08003	0.00083	0.05668	0.00096	492.3	7.6	496.3	4.9	474	38	100.81
101	0.63	0.013	0.08022	0.00094	0.0569	0.0011	495.5	8.1	497.4	5.6	481	43	100.38
102	0.638	0.013	0.08024	0.00097	0.05803	0.0008	501.1	8	497.5	5.8	532	29	99.28
103	0.628	0.017	0.08027	0.00097	0.0567	0.0013	494.5	10	497.7	5.8	483	52	100.65
104	0.626	0.015	0.08029	0.00089	0.05665	0.001	492.9	9.2	497.8	5.3	473	40	100.99
105	0.64	0.017	0.0805	0.00092	0.0578	0.0013	501.8	10	499.1	5.5	534	48	99.46
106	0.632	0.017	0.08053	0.00087	0.0571	0.0013	497.8	11	499.3	5.2	491	49	100.30
107	0.641	0.013	0.08058	0.00098	0.05734	0.00084	502.4	8.3	499.6	5.8	501	32	99.44
108	0.623	0.014	0.08061	0.0008	0.0566	0.0011	491.6	8.5	499.7	4.8	475	43	101.65
109	0.63	0.017	0.08062	0.00084	0.0568	0.0012	495.7	10	499.8	5	480	47	100.83
110	0.627	0.016	0.0806	0.0013	0.0567	0.0012	494	10	499.9	7.5	488	48	101.19
111	0.6373	0.012	0.08065	0.00085	0.05734	0.00083	500.4	7.5	500	5.1	501	32	99.92
112	0.631	0.016	0.08067	0.0009	0.0567	0.0013	496.4	9.9	500.1	5.4	489	48	100.75
113	0.635	0.014	0.08068	0.0011	0.05682	0.00097	498.6	8.5	500.1	6.3	479	38	100.30
114	0.639	0.017	0.08068	0.00086	0.0575	0.0013	501	10	500.2	5.1	508	52	99.84
115	0.6274	0.012	0.08069	0.00089	0.05627	0.00094	494.2	7.6	500.2	5.3	458	37	101.21
116	0.6411	0.012	0.08079	0.0008	0.0578	0.001	503.7	7.8	500.8	4.8	516	39	99.42
117	0.637	0.016	0.08083	0.00087	0.0569	0.0011	499.8	9.7	501.1	5.2	482	44	100.26
118	0.6319	0.012	0.08087	0.00079	0.05652	0.0009	497.1	7.6	501.3	4.7	468	35	100.84
119	0.636	0.013	0.08103	0.0009	0.0572	0.0011	499.6	8.3	502.2	5.4	497	40	100.52
120	0.638	0.017	0.08108	0.00082	0.057	0.0013	500.3	11	502.5	4.9	480	52	100.44
121	0.6403	0.012	0.08112	0.00078	0.05668	0.00087	502.3	7.2	502.8	4.6	480	35	100.10
122	0.656	0.014	0.08115	0.0009	0.05827	0.001	512.2	8.7	503	5.4	545	37	98.20
123	0.654	0.016	0.0812	0.0012	0.0589	0.0013	510.8	10	503.1	6.9	565	47	98.49

124	0.636	0.014	0.08124	0.00094	0.05666	0.001	499.3	8.5	503.5	5.6	472	40	100.84
125	0.642	0.016	0.08127	0.00098	0.0577	0.0012	503.2	10	503.7	5.9	511	47	100.10
126	0.6448	0.013	0.08139	0.00097	0.05753	0.00079	505	7.9	504.4	5.8	509	30	99.88
127	0.644	0.022	0.08143	0.00086	0.0574	0.0018	504	13	504.6	5.2	508	65	100.12
128	0.668	0.037	0.0814	0.0012	0.0593	0.0029	523	24	504.8	6.9	627	100	96.52
129	0.647	0.013	0.08155	0.00098	0.05782	0.00087	507.4	8.6	505.3	5.9	519	33	99.59
130	0.653	0.014	0.08172	0.00092	0.05759	0.00096	510.3	8.4	506.3	5.5	510	36	99.22
131	0.631	0.013	0.08175	0.001	0.0563	0.0012	496.3	8.2	506.5	6.1	456	46	102.06
132	0.651	0.014	0.0818	0.0012	0.05769	0.00088	508.7	8.8	506.6	7	519	35	99.59
133	0.646	0.017	0.08178	0.00087	0.0574	0.0014	506.6	10	506.7	5.2	501	56	100.02
134	0.631	0.028	0.0818	0.0012	0.0562	0.0027	496	17	506.8	7.1	450	110	102.18
135	0.643	0.019	0.08183	0.001	0.0571	0.0016	504	12	507	6	512	62	100.60
136	0.645	0.016	0.08185	0.001	0.0566	0.0011	506.1	10	507.1	6.2	475	41	100.20
137	0.6489	0.012	0.08198	0.0011	0.05732	0.00087	507.6	7.3	507.9	6.5	506	32	100.06
138	0.665	0.015	0.08203	0.00098	0.0587	0.0011	517.6	9	508.2	5.8	558	43	98.18
139	0.6535	0.012	0.08218	0.00082	0.05807	0.00077	510.4	7.6	509.7	5	533	30	99.86
140	0.678	0.015	0.08232	0.00091	0.0599	0.0011	525.5	8.9	509.9	5.4	603	38	97.03
141	0.6487	0.012	0.08251	0.00083	0.05663	0.00079	507.5	7.5	511.1	4.9	483	33	100.71
142	0.65	0.018	0.08251	0.0011	0.0574	0.0014	508.1	11	511.1	6.3	516	54	100.59
143	0.665	0.015	0.08267	0.00094	0.059	0.0013	517.4	9.3	512	5.6	570	47	98.96
144	0.65	0.015	0.0828	0.00092	0.057	0.0012	508.1	9.2	512.8	5.5	499	43	100.93
145	0.664	0.015	0.08321	0.00095	0.0578	0.0011	516.6	9	515.2	5.6	530	42	99.73
146	0.664	0.015	0.0838	0.00093	0.0576	0.0011	516.4	9.4	518.7	5.5	515	44	100.45
147	0.67	0.014	0.084	0.0012	0.0583	0.0009	520.6	8.6	519.7	7	539	34	99.83
148	0.656	0.019	0.084	0.0012	0.0572	0.0015	514	12	520	7.2	489	57	101.17
149	0.669	0.014	0.08435	0.00084	0.0577	0.001	519.7	8.5	522	5	518	39	100.44
150	0.673	0.02	0.0844	0.0012	0.058	0.0014	522	12	522.5	7.4	525	54	100.10
151	0.663	0.018	0.0846	0.0013	0.0578	0.0014	515.6	11	523.7	7.5	520	50	101.57
152	0.747	0.019	0.09142	0.0011	0.059	0.0014	566.1	11	563.9	6.4	571	49	99.61
153	0.767	0.023	0.09309	0.0012	0.0599	0.0014	579	13	573.8	6.8	592	52	99.10
154	0.843	0.03	0.0993	0.0016	0.0622	0.0022	621	17	610.4	9.3	657	76	98.29

15DL9, rhyolite, Group I (Ediacaran)

# Isotopic ratios (and 2σ errors)							Isotopic ages (and 2σ errors)							Disc.
207Pb/ 235U		206Pb/ 238U		207Pb/ 206Pb			207Pb/ 235U		206Pb/ 238U		207Pb/ 206Pb			
	%±		%±		%±			±		±		±		%
155	0.645	0.017	0.08011	0.0011	0.059	0.0015	508.5	10	496.8	6.4	560	54	97.70	
156	0.653	0.014	0.08189	0.00088	0.0574	0.0011	509.9	8.3	507.4	5.2	509	40	99.51	
157	0.71	0.015	0.0871	0.00097	0.0589	0.0012	544.2	8.9	538.3	5.8	569	41	98.92	
158	0.744	0.042	0.0876	0.0021	0.0619	0.0038	563	25	541	12	630	130	96.09	
159	0.725	0.018	0.08955	0.0011	0.0587	0.0014	552.8	11	552.9	6.5	568	51	100.02	
160	0.73	0.015	0.0896	0.001	0.0592	0.0011	556.1	8.9	553.1	5.9	579	41	99.46	
161	0.73	0.017	0.08972	0.00096	0.0592	0.0014	556	10	553.8	5.7	579	48	99.60	
162	0.735	0.014	0.09003	0.001	0.05926	0.00089	560.3	8.2	555.7	6.2	577	32	99.18	
163	0.733	0.016	0.0901	0.0013	0.05886	0.00092	558.1	9.5	556.3	7.6	567	32	99.68	
164	0.712	0.015	0.0902	0.0016	0.0584	0.0014	547.9	10	557	9.7	541	51	101.66	
165	0.742	0.022	0.0907	0.00095	0.0588	0.0016	563	13	559.7	5.6	555	58	99.41	
166	0.729	0.015	0.09073	0.0011	0.05817	0.00094	555.7	8.5	559.8	6.6	537	37	100.74	
167	0.757	0.023	0.0908	0.0013	0.0604	0.0014	572	13	560.1	7.5	615	49	97.92	
168	0.749	0.017	0.09134	0.001	0.0596	0.0013	568.3	10	563.4	6.2	580	49	99.14	

169	0.762	0.022	0.09145	0.00094	0.0599	0.0016	574	12	564.1	5.6	597	60	98.28
170	0.753	0.018	0.0915	0.0012	0.0596	0.0013	569.5	10	564.4	7.3	581	49	99.10
171	0.755	0.031	0.0918	0.0014	0.0602	0.0024	571	18	566.2	8.2	607	83	99.16
172	0.756	0.014	0.09201	0.0009	0.05968	0.00092	571.6	8.1	567.4	5.3	597	33	99.27
173	0.77	0.022	0.0923	0.0013	0.0602	0.0016	579	12	569.1	7.7	606	55	98.29
174	0.74	0.015	0.09244	0.00092	0.05816	0.00085	562.4	8.9	569.9	5.4	534	33	101.33
175	0.7636	0.013	0.09265	0.00096	0.06001	0.00077	576	7.2	571.1	5.7	602	27	99.15
176	0.759	0.017	0.09275	0.001	0.0599	0.0011	573.1	9.7	571.8	5.9	593	40	99.77
177	0.784	0.019	0.0935	0.0013	0.0604	0.0015	587.2	11	576.5	7.4	619	55	98.18
178	0.756	0.015	0.09374	0.00097	0.0585	0.00095	571.4	8.5	577.6	5.7	550	34	101.09
179	0.783	0.029	0.0951	0.0015	0.0599	0.002	586	16	585.4	8.6	614	68	99.90
180	0.781	0.02	0.09555	0.0012	0.0596	0.0012	585.2	11	588.3	6.8	583	44	100.53
181	0.793	0.02	0.09563	0.0011	0.0601	0.0013	594.3	11	588.7	6.2	619	41	99.06
182	0.7835	0.014	0.09577	0.00099	0.05941	0.00095	587.2	7.8	589.5	5.8	582	34	100.39
183	0.7971	0.013	0.09593	0.00094	0.06018	0.00072	595.8	7.2	590.5	5.5	611	25	99.11
184	0.796	0.017	0.09625	0.001	0.05989	0.001	594.2	9.7	592.4	5.9	604	39	99.70
185	0.784	0.017	0.0964	0.0014	0.0587	0.0011	587.4	9.5	593.3	8.1	559	41	101.00
186	0.792	0.021	0.09683	0.0011	0.0593	0.0014	594.2	11	595.8	6.5	583	49	100.27
187	0.781	0.021	0.09688	0.001	0.0588	0.0012	586	12	596.1	6	561	44	101.72
188	0.795	0.021	0.09696	0.0011	0.0595	0.0014	595	12	596.5	6.6	574	53	100.25
189	0.796	0.021	0.097	0.0012	0.0587	0.0013	595	12	597.6	6.9	561	48	100.44
190	0.812	0.015	0.09719	0.00099	0.06024	0.00085	603.5	8.2	597.9	5.8	609	30	99.07
191	0.806	0.02	0.0972	0.0012	0.0603	0.0013	599.6	11	597.9	7	608	45	99.72
192	0.84	0.023	0.0976	0.0013	0.062	0.002	618	13	600.2	7.9	672	67	97.12
193	0.805	0.015	0.09767	0.0009	0.05995	0.00081	599.6	8.3	600.7	5.3	599	29	100.18
194	0.822	0.021	0.09776	0.001	0.061	0.0013	609.8	11	601.2	6	630	45	98.59
195	0.821	0.017	0.09812	0.0011	0.06068	0.00099	608.5	9.2	603.3	6.5	628	36	99.15
196	0.801	0.018	0.09816	0.0011	0.0596	0.0011	597.9	11	603.6	6.7	583	40	100.95
197	0.82	0.022	0.09816	0.001	0.0607	0.0014	607	12	603.6	6	618	51	99.44
198	0.803	0.016	0.09822	0.001	0.05952	0.0009	598.1	8.9	603.9	5.9	582	33	100.97
199	0.828	0.018	0.09868	0.0012	0.061	0.0011	612.1	10	606.7	6.8	638	40	99.12
200	0.829	0.021	0.09873	0.0012	0.061	0.0014	614	12	606.9	6.8	643	46	98.84
201	0.844	0.025	0.0996	0.0022	0.0611	0.0011	620	13	612	13	637	40	98.71
202	0.844	0.016	0.10096	0.001	0.06016	0.0009	621	8.9	620	5.9	614	34	99.84
203	0.836	0.026	0.1012	0.0013	0.0602	0.0018	618	14	621.2	7.3	605	69	100.52
204	0.845	0.015	0.10107	0.00097	0.06032	0.00085	621.6	8.2	621.3	5.5	612	31	99.95
205	0.857	0.02	0.10224	0.0011	0.06089	0.0011	629.3	11	627.5	6.7	630	37	99.71
206	1.042	0.028	0.1192	0.0024	0.06349	0.00098	724	14	726	14	721	33	100.28

15DL11, matrix of metaconglomerate, Group I (upper Ediacaran/lower Cambrian)

# Isotopic ratios (and 2 σ errors)							Isotopic ages (and 2 σ errors)						Disc.
207Pb/ 235U		206Pb/ 238U		207Pb/ 206Pb			207Pb/ 235U		206Pb/ 238U		207Pb/ 206Pb		
	% $\pm$		% $\pm$		% $\pm$			$\pm$		$\pm$		$\pm$	%
207	0.724	0.016	0.08878	0.0011	0.05857	0.0011	553.6	9	548.3	6.4	562	38	99.04
208	0.7377	0.013	0.09033	0.00093	0.05938	0.00078	560.9	7.7	557.5	5.5	582	28	99.39
209	0.722	0.021	0.0912	0.0015	0.0579	0.0018	554	14	562.3	8.8	517	70	101.50
210	0.752	0.014	0.09228	0.00098	0.05915	0.00083	569.3	8.3	569	5.8	573	30	99.95
211	0.76	0.015	0.09221	0.00098	0.05987	0.00095	573.7	8.8	569.2	5.6	594	35	99.22
212	0.756	0.023	0.0936	0.0012	0.0588	0.0016	570	13	576.7	7.3	553	56	101.18
213	0.766	0.017	0.0946	0.0017	0.05846	0.00082	577.2	9.6	582.6	10	553	31	100.94

214	0.78	0.014	0.09593	0.001	0.05927	0.00092	585.3	8.2	590.5	5.9	577	33	100.89
215	0.813	0.016	0.09751	0.0011	0.0603	0.00099	604.8	9.2	599.8	6.3	610	35	99.17
216	0.827	0.016	0.098	0.0012	0.0614	0.001	612.7	9.5	602.9	7.3	648	36	98.40
217	0.824	0.015	0.09954	0.00099	0.05979	0.0011	610	8	611.7	5.8	591	38	100.28
218	0.838	0.017	0.0996	0.0013	0.0611	0.0012	617.7	9.7	613.1	7.3	635	41	99.26
219	0.866	0.024	0.10158	0.0012	0.0615	0.0014	634	13	623.7	7.1	656	51	98.38

15DL12, quartz sandstone ("El Hank quartzite"), Group IV (upper Cambrian)

# Isotopic ratios (and 2 σ errors)							Isotopic ages (and 2 σ errors)						Disc.
	207Pb/ 235U	% $\pm$	206Pb/ 238U	% $\pm$	207Pb/ 206Pb	% $\pm$	207Pb/ 235U	$\pm$	206Pb/ 238U	$\pm$	207Pb/ 206Pb	$\pm$	%
220	0.815	0.022	0.09676	0.0012	0.0608	0.0015	607	12	595.4	6.8	639	51	98.09
221	0.99	0.026	0.111	0.0016	0.0641	0.0015	698	14	678.6	9.1	739	51	97.22
222	1.742	0.034	0.1714	0.002	0.07394	0.001	1023.6	13	1019.7	11	1041	28	99.62
223	0.809	0.029	0.0971	0.0014	0.06	0.0019	600	16	597.5	8.2	593	72	99.58
224	6.282	0.097	0.37	0.0042	0.1231	0.0013	2015.5	14	2029	20	2001	19	100.67
225	0.812	0.024	0.0996	0.0015	0.0591	0.0017	603	13	611.8	9	563	62	101.46
226	0.837	0.025	0.0985	0.0012	0.0621	0.0015	616	14	605.7	7.3	681	55	98.33
227	4.64	0.1	0.315	0.0046	0.1082	0.0019	1760	18	1765	23	1771	31	100.28
228	0.988	0.028	0.1178	0.0022	0.062	0.0015	699	13	718	13	664	52	102.72
229	7.084	0.11	0.3923	0.0046	0.1309	0.0014	2121.4	14	2133	21	2111	19	100.55
230	4.608	0.078	0.3118	0.0034	0.1076	0.0013	1750.1	14	1750	17	1764	23	99.99
231	0.863	0.019	0.1036	0.0014	0.0605	0.0012	631.1	11	635.3	8	620	41	100.67
232	5.13	0.15	0.3339	0.0049	0.1117	0.003	1838	24	1857	24	1831	46	101.03
233	6.49	0.18	0.3761	0.0054	0.1249	0.0028	2043	24	2058	25	2023	40	100.73
234	6.325	0.11	0.3675	0.0044	0.1242	0.0013	2021	16	2017	21	2016	19	99.80

235	0.824	0.019	0.09738	0.001	0.0608	0.0012	609.8	11	599	6	624	44	98.23
236	0.816	0.029	0.0987	0.0016	0.0601	0.0019	604	16	606.5	9.2	588	70	100.41
237	0.786	0.02	0.09408	0.0011	0.0601	0.0013	588.6	11	579.6	6.5	599	48	98.47
238	0.798	0.021	0.09645	0.0011	0.0602	0.0014	596	12	593.6	6.4	613	51	99.60
239	5.09	0.15	0.3236	0.0043	0.1143	0.003	1833	25	1807	21	1873	51	98.58
240	0.872	0.018	0.10367	0.0012	0.06078	0.00094	636.2	9.8	635.9	7	636	35	99.95
241	0.874	0.021	0.1053	0.0013	0.0602	0.0013	637	12	645.1	7.4	600	49	101.27
242	7.04	0.17	0.3937	0.0054	0.1298	0.0021	2117	22	2140	25	2095	28	101.09
243	0.851	0.023	0.0999	0.0013	0.0618	0.0016	626	12	613.8	7.5	652	58	98.05
244	7.177	0.11	0.3897	0.0045	0.13419	0.0012	2133.2	14	2121	21	2153	16	99.43
245	6.167	0.091	0.3643	0.0035	0.12264	0.0011	1999.5	13	2002	17	1994	16	100.13
246	0.82	0.018	0.0971	0.0013	0.0614	0.0013	607.9	9.7	597.6	7.6	649	46	98.31
247	1.418	0.041	0.151	0.002	0.0673	0.0016	895	17	906.2	11	863	49	101.25
248	0.802	0.026	0.0989	0.0012	0.0585	0.0016	599	14	607.9	7	550	63	101.49
249	0.839	0.021	0.10151	0.0012	0.06	0.0012	618	12	623.2	7.2	597	44	100.84
250	0.909	0.025	0.1094	0.0017	0.0602	0.0013	655	13	669.1	9.9	601	48	102.15
251	5.803	0.088	0.3543	0.0038	0.1191	0.0011	1946.4	13	1955	18	1944	17	100.44
252	0.945	0.02	0.1122	0.0013	0.0606	0.0012	675.2	10	685.5	7.3	638	47	101.53
253	0.759	0.023	0.09307	0.0011	0.0593	0.0016	572	13	573.6	6.4	579	58	100.28
254	13.4	0.27	0.5187	0.0068	0.1866	0.003	2710	18	2693	29	2716	26	99.37
255	1.996	0.084	0.1882	0.0034	0.0766	0.0028	1109	28	1112	19	1098	73	100.27
256	6.071	0.11	0.3573	0.0042	0.1225	0.0016	1987	15	1969	20	1995	22	99.09
257	6.75	0.14	0.3785	0.0057	0.1305	0.0015	2081	18	2069	26	2104	20	99.42
258	0.872	0.016	0.10265	0.0011	0.0616	0.0009	636.3	8.4	629.9	6.6	657	31	98.99
259	6.273	0.1	0.3648	0.0037	0.1256	0.0015	2014.2	14	2005	17	2036	22	99.54
260	0.807	0.016	0.09712	0.0011	0.06005	0.00095	600.2	9.1	597.5	6.2	615	34	99.55
261	0.875	0.022	0.1015	0.0014	0.0624	0.0014	638	12	623.1	8	691	45	97.66
262	0.7938	0.014	0.09617	0.0011	0.05987	0.00081	593.1	7.8	591.9	6.3	596	29	99.80
263	0.828	0.02	0.0979	0.0012	0.0609	0.0014	612.4	11	602	7.1	655	49	98.30
264	0.938	0.017	0.1102	0.0014	0.06194	0.00085	671.5	8.7	673.6	7.9	669	29	100.31
265	0.781	0.026	0.0958	0.0012	0.0591	0.0018	587	14	589.7	6.8	551	68	100.46
266	0.828	0.02	0.10052	0.0012	0.0597	0.0012	613.7	11	617.4	6.8	600	42	100.60
267	0.858	0.023	0.1042	0.0013	0.0601	0.0015	630	12	638.8	7.6	605	55	101.40
268	0.878	0.018	0.10426	0.0011	0.06139	0.00096	641.9	9.1	639.3	6.2	653	33	99.59
269	0.822	0.023	0.09637	0.0012	0.0606	0.0015	608	13	593.1	6.9	649	55	97.55
270	6.269	0.091	0.3665	0.0037	0.12364	0.0012	2013.9	13	2015	18	2009	18	100.05
271	9.4	0.17	0.4466	0.0067	0.1542	0.002	2377	17	2379	30	2392	22	100.08
272	0.833	0.032	0.1035	0.0016	0.0578	0.0022	616	17	634.9	9.4	506	85	103.07
273	6.424	0.096	0.3723	0.0036	0.12534	0.0011	2036.2	13	2040	17	2035	16	100.19
274	6.499	0.12	0.3745	0.0057	0.12575	0.0013	2045	17	2050	27	2039	18	100.24
275	0.8249	0.014	0.09838	0.0011	0.06072	0.00075	610.6	7.9	604.9	6.3	627	26	99.07
276	4.88	0.12	0.3159	0.0048	0.1119	0.0022	1797	21	1769	23	1832	35	98.44
277	0.791	0.038	0.0964	0.0017	0.0589	0.003	592	21	592.9	9.8	540	110	100.15
278	13.74	0.24	0.5243	0.0054	0.1897	0.0019	2731	17	2717	23	2739	16	99.49
279	0.888	0.026	0.1069	0.0013	0.0601	0.0017	645	14	654.9	7.8	603	60	101.53
280	0.76	0.025	0.09333	0.0011	0.0587	0.0019	573	14	575.2	6.6	554	74	100.38
281	0.862	0.016	0.10157	0.0011	0.06155	0.00082	630.7	8.8	623.6	6.4	656	29	98.87
282	6.673	0.11	0.3776	0.004	0.1275	0.0014	2068.4	15	2065	19	2068	18	99.84
283	5.12	0.11	0.33	0.0045	0.1123	0.002	1838	18	1838	22	1844	33	100.00
284	6.778	0.1	0.3797	0.0039	0.12964	0.0012	2083.7	14	2077	18	2092	16	99.68
285	6.19	0.18	0.3627	0.0058	0.1251	0.0035	2000	25	1998	28	2026	48	99.90
286	6.01	0.15	0.3637	0.0065	0.1205	0.0026	1979	23	1999	31	1961	39	101.01
287	0.791	0.019	0.09729	0.0011	0.0591	0.0013	591	11	598.5	6.6	569	48	101.27

288	0.913	0.033	0.1099	0.0015	0.0602	0.0022	659	18	671.9	8.8	610	76	101.96
289	1.017	0.022	0.1169	0.0015	0.06345	0.00096	714.6	11	712.8	8.4	720	32	99.75
290	5.84	0.19	0.3466	0.0063	0.1232	0.0045	1954	28	1918	30	2011	63	98.16
291	6.389	0.11	0.3687	0.0043	0.1254	0.0014	2031.6	15	2023	20	2034	20	99.58

Data not used for calculations and plots

15DL1, rhyolite, Group I (Ediacaran)

# Isotopic ratios (and 2σ errors)							Isotopic ages (and 2σ erros)							Disc.
207Pb/		206Pb/		207Pb/		207Pb/	207Pb/	206Pb/		207Pb/	±	%		
235U	%±	238U	%±	206Pb	235U		±	238U	± 206/Pb					
292	0.869	0.018	0.08848	0.0011	0.071	0.0014	637.2	9.8	546.5	6.3	963	39	85.77	

15DL6, greywacke, Group III (upper Cambrian)

#	# Isotopic ratios (and 2σ errors)						Isotopic ages (and 2σ erros)						Disc.
	207Pb/		206Pb/		207Pb/		207Pb/		206Pb/		207Pb/		
	235U	%±	238U	%±	206Pb	%±	235U	±	238U	±	206/Pb	±	
293	0.6442	0.01	0.0635	0.0021	0.0743	0.0027	504.8	6.5	397	13	1045	72	78.65
294	0.7696	0.013	0.02392	0.00034	0.2358	0.0046	579.4	7.5	152.4	2.1	3092	31	26.30
295	0.738	0.017	0.07792	0.00085	0.0687	0.0014	560.6	9.7	483.7	5.1	883	41	86.28
296	1.018	0.046	0.08277	0.00096	0.0889	0.0034	709	23	512.6	5.7	1387	74	72.30
297	0.785	0.038	0.0633	0.0042	0.096	0.011	586	21	395	25	1430	210	67.41
298	1.58	0.52	0.084	0.0047	0.123	0.031	840	160	519	27	1690	390	61.79
299	0.679	0.016	0.07769	0.00088	0.0629	0.0014	527.2	9.9	482.3	5.3	710	48	91.48
300	2.16	0.25	0.0899	0.0021	0.167	0.016	1138	80	555	13	2430	160	48.77
301	0.849	0.025	0.0822	0.0013	0.075	0.0022	625	14	508.9	7.6	1064	57	81.42
302	0.701	0.017	0.0608	0.0013	0.0839	0.0026	539	10	380.2	8.1	1286	60	70.54
303	0.6107	0.011	0.07222	0.00085	0.06127	0.00087	483.9	7	449.5	5.1	645	31	92.89
304	1.82	0.18	0.08072	0.001	0.162	0.015	1027	59	500.4	6.1	2380	150	48.72
305	0.6875	0.012	0.06774	0.001	0.07339	0.001	531.2	7.1	422.5	6.3	1025	29	79.54
306	0.6075	0.012	0.06666	0.00089	0.06584	0.001	481.8	7.4	416	5.4	802	33	86.34
307	0.781	0.014	0.06211	0.00081	0.0915	0.0012	586	8.1	388.4	4.9	1459	25	66.28
308	0.902	0.024	0.0724	0.0016	0.0903	0.0038	654	13	450.7	9.3	1452	83	68.91
309	2.52	0.44	0.0941	0.0034	0.18	0.026	1160	130	579	20	2290	290	49.91
310	0.6784	0.012	0.07454	0.00095	0.06571	0.001	525.6	7.4	463.4	5.7	793	32	88.17
311	0.7055	0.013	0.0746	0.0014	0.06826	0.001	541.9	7.9	464	8.2	873	31	85.62
312	0.586	0.017	0.0712	0.0012	0.0605	0.0016	468	11	443.3	7.4	619	56	94.72
313	0.693	0.026	0.0812	0.0024	0.0623	0.0024	534	16	503	14	677	82	94.19
314	0.65	0.014	0.0689	0.0026	0.0694	0.0027	508	8.6	429	15	894	82	84.45
315	0.669	0.013	0.03251	0.00044	0.1497	0.0018	519.9	7.6	206.2	2.7	2342	20	39.66
316	0.6554	0.011	0.07457	0.00087	0.06374	0.00085	512.4	7.2	463.6	5.2	730	28	90.48
317	0.606	0.023	0.0474	0.0046	0.1022	0.0089	483	14	298	28	1530	170	61.70
318	0.555	0.013	0.0632	0.0017	0.0643	0.002	448	8.4	394.8	10	750	67	88.13
319	0.4744	0.009	0.0388	0.0014	0.0892	0.0025	394.1	6.2	245.4	8.5	1404	53	62.27
320	0.702	0.025	0.0819	0.0019	0.0629	0.0023	540	15	507	11	696	78	93.89
321	4.05	0.95	0.1121	0.0095	0.217	0.037	1380	190	682	55	2510	310	49.42
322	0.881	0.023	0.0457	0.0036	0.153	0.012	641	12	288	22	2330	140	44.93

323	0.533	0.016	0.0599	0.0012	0.0652	0.0014	433.5	10	375.1	7.1	778	43	86.53
324	0.584	0.013	0.05075	0.0008	0.08347	0.00093	466.7	8.2	319.1	4.9	1282	23	68.37
325	0.692	0.02	0.0594	0.0025	0.0868	0.0055	533	12	372	15	1310	120	69.79
326	0.566	0.014	0.0626	0.0011	0.0659	0.0011	455.2	9.2	391.4	6.7	802	35	85.98
327	0.6298	0.01	0.05991	0.0011	0.077	0.0019	495.9	6.5	375.1	6.4	1110	49	75.64
328	0.909	0.029	0.0682	0.0012	0.098	0.0041	655	15	425	7.4	1557	80	64.89

15DL9, rhyolite, Group I (Ediacaran)

# Isotopic ratios (and 2σ errors)							Isotopic ages (and 2σ errors)						Disc.
207Pb/ 235U	%±	206Pb/ 238U	%±	207Pb/ 206Pb	%±		207Pb/ 235U	±	206Pb/ 238U	±	207Pb/ 206Pb	±	%
329	0.797	0.038	0.0907	0.0022	0.0639	0.003	594	22	560	13	750	110	94.28
330	0.7545	0.013	0.08224	0.00099	0.06704	0.00088	570.7	7.4	509.5	5.9	837	27	89.28
331	0.836	0.017	0.09786	0.0012	0.06138	0.00091	616.5	9.3	601.8	7.1	657	29	97.62
332	0.7601	0.014	0.09099	0.001	0.06044	0.00088	574	7.8	561.4	6	618	32	97.80
333	0.822	0.022	0.094	0.0011	0.0637	0.0014	611	12	579.1	6.6	737	47	94.78
334	0.733	0.036	0.0848	0.0015	0.0634	0.0027	559	21	524.7	8.7	713	93	93.86
335	0.719	0.019	0.0819	0.0013	0.0632	0.0014	549	12	507.3	7.6	715	46	92.40
336	0.96	0.033	0.0788	0.0013	0.0886	0.0036	684	18	489.1	8	1389	83	71.51
337	0.9	0.038	0.0937	0.0015	0.0693	0.002	649	20	577.2	9.1	902	56	88.94
338	0.7154	0.013	0.0779	0.0013	0.06659	0.00088	548.6	7.4	483.5	7.7	837	26	88.13
339	0.657	0.014	0.078	0.0014	0.06128	0.00071	512.5	8.7	484.2	8.4	647	25	94.48

15DL11, matrix of metaconglomerate, Group I (upper Ediacaran/lower Cambrian)

# Isotopic ratios (and 2σ errors)							Isotopic ages (and 2σ errors)						Disc.
207Pb/ 235U	%±	206Pb/ 238U	%±	207Pb/ 206Pb	%±		207Pb/ 235U	±	206Pb/ 238U	±	207Pb/ 206Pb	±	%
340	2.934	0.075	0.2094	0.0051	0.10135	0.0011	1389	19	1229	27	1648	21	88.48
341	2.21	0.23	0.082	0.0025	0.195	0.02	1169	71	508	15	2760	190	43.46
342	1.163	0.085	0.0888	0.0021	0.096	0.0056	779	39	548	12	1490	110	70.35

15DL12, quartz sandstone ("El Hank quartzite"), Group IV (upper Cambrian)

# Isotopic ratios (and 2σ errors)							Isotopic ages (and 2σ errors)						Disc.
207Pb/ 235U	%±	206Pb/ 238U	%±	207Pb/ 206Pb	%±		207Pb/ 235U	±	206Pb/ 238U	±	207Pb/ 206Pb	±	%
343	1.013	0.023	0.11	0.0014	0.0668	0.0013	680	13	580.8	6.9	1023	46	85.41
344	0.955	0.025	0.09428	0.0012	0.0732	0.0017	1334	29	1139	28	1653	30	85.38
345	6.813	0.12	0.393	0.0057	0.12507	0.0013	2104	22	2023	27	2196	37	96.15
346	6.91	0.19	0.3687	0.0058	0.1377	0.003	602.8	8.7	548.6	7.6	834	38	91.01
347	0.811	0.016	0.0888	0.0013	0.0666	0.0012	1991	16	1864	18	2129	20	93.62
348	6.614	0.12	0.3806	0.0038	0.1263	0.0015	2630	18	2424	21	2786	26	92.17
349	10.48	0.24	0.4499	0.0059	0.1679	0.0025	649	12	613.6	10	789	46	94.55
350	0.896	0.022	0.0999	0.0017	0.0656	0.0014	1434	27	1145	26	1911	23	79.85
351	7.65	0.15	0.3914	0.0053	0.1406	0.0017	1697.8	14	1251	23	2299	32	73.68

352	4.326	0.074	0.2142	0.0044	0.1459	0.0027	2317	20	2639	35	2046	23	113.90
353	1.853	0.034	0.1711	0.002	0.07891	0.00099	1943	18	1914	19	1969	26	98.51
354	5.785	0.12	0.3458	0.004	0.1207	0.0018	2064	23	2101	43	2022	34	101.79
355	6.61	0.18	0.3854	0.0091	0.1247	0.0024	965	25	601.1	9.8	1974	82	62.29
356	1.596	0.067	0.0977	0.0017	0.1214	0.0054	684	19	595.9	6.5	972	69	87.12
357	0.96	0.036	0.09685	0.0011	0.0719	0.0025	1162	15	436.2	6	2979	45	37.54
358	2.144	0.047	0.07002	0.001	0.2203	0.0061	601.6	10	525.9	6.2	887	34	87.42
359	0.809	0.018	0.085	0.001	0.0688	0.0011	1990	24	1473	37	2583	26	74.02
360	6.12	0.17	0.2569	0.0072	0.1726	0.0028	2234	16	2031	23	2425	15	90.91
361	8.04	0.14	0.3705	0.005	0.15713	0.0014	1990	22	1960	26	2031	35	98.49
362	6.11	0.15	0.3547	0.0055	0.1252	0.0025	2351.4	14	2282	22	2412	19	97.05
363	9.138	0.14	0.4236	0.0045	0.1556	0.0017	681	17	570.6	6.1	1057	58	83.79
364	0.959	0.033	0.09256	0.001	0.0748	0.0021	1621	23	1310	27	2056	19	80.81
365	3.933	0.11	0.2255	0.0052	0.1269	0.0013	1910	270	960	110	2990	380	50.26
366	8.9	2.2	0.163	0.019	0.322	0.057	2580	16	2408	29	2729	15	93.33
367	11.95	0.19	0.4898	0.0059	0.1771	0.0016	663	14	629.8	8.3	773	43	94.99

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