**Table S1.** List of paleontological records of ball-shaped spicules (sterrasters, aspidasters, selenasters, rhaxes), classified from the oldest (Cambrian) to the most recent records (Miocene). Whenever the term ‘rhax’ is used in publications it entails that it is a reniform-shaped spicule. ‘?‘ means missing data or unknown identification. Colors stand for periods: blue for Jurassic, green for Cretaceous and light orange for Paleogene. In purple, comments on the identifications given in the papers.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Epoch/Age,**  **Period,**  **Age (Ma)** | **Locality** | **Morphology (illustration)** | **Abundance (with respect to all spicules)** | **Size of ball-shaped spicules**  **(µm)** | **Siliceous or calcite** | **Environment lithology, depth estimate** | **Identification by authors**  **Revised id or comments (this study)** | **references** |
| Epoch 3,  Early Cambrian (497.0) | Archaeocyath mound of the Flinders Ranges, Wilkawillina Limestone, Australia | subpherical to reniform, surface not visible  (SEM) | ? | ~200  (measured from plate 3, figs. 3-4) | recrystallized | shallow | ? (too little information) | Gruber & Reitner (1995, Plate 3, figs. 3-4)  Reitner & Mehl (1995, Plate, fig.4) |
| Tremadocian,  Early Ordovician (477.7) | Windfall Formation, Antelope Range, Nevada, USA | “rhax”  (SEM) | one | ~1000  (measured from plate 5, figs. 8-9) | recrystallized | outermost shelf or slope facies | ? (the size is too big to be a selenaster) | Kozur et al. (1996) |
| Asbian-Namurian  Carboniferous  (346.7-313) | Yoredale series, Richmond, Yorkshire | “rhax”  (drawing) | few | 130-200 | ? | ? | *~~Geodites~~ cornatus*  The “rhax” are a petrosiid microstrongyle according to (Wiedenmeyer, 1994) | Hinde (1888) |
| Hettangian sup. to Sinemurien sup.,  Early Jurassic (199.3-190.8) | Allgäu formation, Northern Calcareous Alps, Austria | rhax  (not illustrated) | rare | ? | ? | deep | *Rhaxella/Rhaxelloides?* | Mostler (1990, p. 129) |
| Late Pliensbachian  Early Jurassic  (~190-182) | Huciska Limestone Formation, Križna Unit, W. Carpathian, Poland | rhax  (SEM) | ? | ~82-89  (measured from fig. 8) | Siliceous with a few calcified | slope <200 m deep | *Rhaxella* sp. | Jach (2002) |
| Late Callovian to Oxfordian  Middle Jurassic  (~164-157) | Brora Arenaceous Formation, Inner Moray Firth, Scotland, UK | rhax moulds | abundant | ? | usually dissolved | ? | *Rhaxella perforata*  *Rhaxella/Rhaxelloides?* | Block Valge et al. (1994) |
| Callovian,  Middle Jurassic  (163-166) | Mughanniyya formation, Tal el Dhahab, Jordan | whole sponge with ‘sterrasters’, plagiotriaenes, dichotriaenes, oxeas, styles  (no SEM) | ? | 140-330 | calcite and rare siliceous spicules | moderate depth | *Geoditesia jordaniensis,*  *Geoditesia* sp., ?*Geoditesia* sp.  ?Geodiidae | Ungureanu et al. (2018) |
| Bathonian  Middle Jurassic  (166.1) | Appennino Campano-Lucano Lagonegro unit, Italy | rhax, spherasters  (SEM) | rare | ~115  (measured from plate 5, fig. 3)  ~100  (measured from plate 5, fig. 2a) | ? | ? | *Rhaxella/Rhaxelloides* | Donofrio (1984) |
| Callovian to early Tithonian  Middle to Late Jurassic  (166.1-150) | Kiritani Formation, Tetori Group,  Yatsao area,  Japan | rhax, sterrasters (spherical)  (SEM) | rhax dominant, rare sterrasters | ~93-140  (measured from fig. 9)  ~113-120  (measured from fig. 9) | ? | shallow | *Rhaxella sorbyana*  *Rhaxelloides sphaerica* | Kashiwagi & Hirasawa (2010) |
| Lower Oxfordian,  Late Jurassic  (163.5) | Jasna Góra Beds, Polish Jura, Poland | rhax, sterrasters (spherical), large spheraster  (drawing) | ? | ? | Calcified + few siliceous remains | sponge megafacies | *Rhaxella sorbyana*  *Rhaxelloides sphaerica*?  *Rhaxelloides* sp. | Trammer (1982) |
| Lower to Middle Oxfordian  Late Jurassic  (163.5-160) | Wrzosowa and Zawodzie (Oxfordian),  Polish Jura,  Poland | rhax (rough grainy surface), sterrasters (spherical, covered with fine lumpy ornamentation),  spheraster  (SEM) | ? | 100-200 (rhax, sterrasters, spherasters) | ? | sponge megafacies | *Rhaxella sorbyana*  *Rhaxelloides sphaerica*?  *Rhaxelloides* sp. | Moczydłowska and Paruch-Kulczycka (1978) |
| Oxfordian  Late Jurassic  (163.5-157.3) | Lower Calcarous Grit, Yorkshire United Kingdom | rhax  (cavity: dark oval spot in the middle + radial structure). | ? | 110-150  thickness: 80 | Calcified and/or siliceous | sponge megafacies | *Rhaxella perforata*  *(= R.sorbyana)* | Hinde (1890) |
| Middle Oxfordian  Late Jurassic  (161.2-155.7) | Bifurcatus zone, West Walton Beds Formation, United Kingdom | rhax  (no illustration) |  |  |  | reef, buildup or bioherm; lithified framestone | *Rhaxella* sp. | Insalaco (1999) |
| Middle Oxfordian (161.2-155.7) | Yorkshire, United Kingdom | rhax  (no illustration) |  |  |  | sand shoal; lithified packstone | *Rhaxella* sp. | Insalaco (1999) |
| Middle Oxfordian (161.2 - 155.7) | Cardioceras tenuiserratum zone, Coral Rag Formation, Oxfordshire, United Kingdom | rhax  (no illustration) |  |  |  | reef, buildup or bioherm; lithified reef rocks | *Rhaxella* sp. | Insalaco (1999) |
| Oxfordian,  Late Jurassic  (163.5-157.3) | Korallenoolith Formation, NW Germany | rhax,  sterrasters  (thick section pictures, some rhax have a black center) | abundant | 110-190 | ? | reef, buildup or bioherm | *Rhaxella sorbyana*  *Rhaxelloides* sp.? | Gramann (1962) |
| Oxfordian,  Late Jurasssic  (163.5-157.3) | North of Priatra Craiului mountains, Carpathes Mountains, Romania | rhax, (no cavity)  sterrasters  (cavity: dark oval spot in the middle + radial structure).  (thick section pictures) | ? | rhax:  130 x 100  sterraster: 190-200 x 160-170 | calcite | ? | *Rhaxella sorbyana*  *Rhaxelloides* sp. | Bucur (1980) |
| Oxfordian,  Late Jurasssic  (163.5-157.3) | Fulmar sandstone, North Sea | rhax  (no description) | ? | ? | ? | shoreface to proximal offshore-transitional zone, warm-temperate to subtropical, clear waters | *Rhaxella sorbyana*  *Rhaxelloides. sphaerica* | Humphrey (2003) |
| Late Oxfordian,  Late Jurasssic  (~160-157.3) | Hennequeville,  Normandy, France | Rhax  (no illustrations) | 5-60% | 100-180 | Calcite or secondarily resilicified |  | *Rhaxella* sp. | Dugué (1995) |
| Callovian to Early Kimmeridgian Middle to Late Jurassic  (163.5-152.1) | Mexico | a) rhax: reniform to oval with small pores on surface, 2 µm wide, separated by 2 µm, no internal structure  b) Spherical, smooth usually but otherwise with the same pores, cavity, radial structure  c) Lentil shaped, smooth, radial structure | abundant | a) 110-150 (65-80 thick)  b) 79-200 x 60-170 (40-90 thick)  c) 90 (50 thick) |  |  | a) *Rhaxella sorbyana*  b) *Rhaxelloides sphaerica*?  c) *Erylus*? | Trejo (1967) |
| Early Kimmeridgian Late Jurassic  (157-155) | Langenberg/Oker,  Germany | whole sponge in oyster valv with reniform sterrasters with dichotriaenes, oxeas, and calthrops. | dominant | 100 x 70 (hilum is 10 µm deep) | sparite and microsparite | oyster patch reef  (shallow sea or bay) | ?*Rhaxella sorbyana*  (= *R. perforata*)  *Raxelloides* sp.? | Delecat et al. (2001) |
| Kimmeridgian, Late Jurassic,  (157.3-152.1) | Swabian Alb, Nattheim,  Germany | rhax,  sterrasters (spherical),  spherasters  (drawing) | rhax (most abundant spicule: 49.7%)  sterrasters (very rare) | 80-200 (rhax)  150  (sterrasters)  150-170  (spherasters) | ? | sponge megafacies | *Rhaxella sorbyana*  *Rhaxelloides sphaerica*?  *Rhaxelloides* sp. | Reif (1967) |
| Upper Kimmeridgian,  Late Jurassic  (152.1) | Swabian Alb, Germany | rhax,  spherasters  (SEM) | 75% | 120-170  (rhax)  170-180  (spherasters) | ? | sponge megafacies | *Rhaxella sorbyana*  *Rhaxelloides sphaerica*? | Pisera (1997, p. 94, pl. 53) |
| Late Kimmeridgian to Early Tithonian,  Late Jurassic (152.1) | Magnus Field, UK North Sea | rhax,  sterrasters (spherical) | dominant | 151-175 (rhax)  95-150 (sterrasters) | Siliceous and pyritized | sand-rich turbidite system | *Rhaxella* sp.  Radiolarian ?*Praeconocaryomma* sp2 (= Geodiidae) | Morris et al. (1999) |
| Tithonian  Late Jurassic  (152.1-145.0) | Winspit, Dorset, United Kingdom | 1) rhax  2) sterrasters (oval)  3) sterrasters (spherical)  4) rhax elongated  5) rhax very elongated | R. sorbyana are dominant | 1) 190-200 x 140-170  2) 210-250 x 120-150  3) 110-120  4) 180-210 x 80-120  5) 160-190 x 50-80 | Calcite to siliceous | Slope, relatively deep | 1) *R. sorbyana*,  2) *Rhaxelloides cilindricas*  3) *Rhaxelloides sphaerica*  4) *Rhaxella elongata* sp. nov.  5) *Rhaxella winspitensi*s sp. nov. | Haslett (1992) |
| Tithonian  Late Jurassic  (152.1-145.0) | Portland Freestone Member, Portland Limestone Formation, United Kingdom | rhax | ? | ? | ? | Oyster reef, buildup or bioherm; lithified reef rocks | *Rhaxella* sp. ? | Fürsich et al. (1994) |
| Tithonian  Late Jurassic  (152.1-145.0) | Lo Valdés Formation, Andes, Chile | rhax  (no illustrations) | ? | ? | calcite | ? | *Rhaxella* sp. | Hallam et al. (1986) |
| Tithonian,  Late Jurassic  (152.1-145.0)  Berriasian  Early Cretaceaous  (145-139) | Picún Leufú formation, Neuquén Bassin, Argentina | rhax,  sterrasters (spherical) | dominant  (80-90%) | 103-127 x  72-96 | Dark rim of the rhaxes is siliceous, while the core is calcite | shallow water | *Rhaxella sorbyana*  *Rhaxelloides sphaerica*? | Afsar et al. (2014) |
| Aptian-Albian,  Early Cretaceous  (125-100.5) | Lower-Upper Greensand,  England  Lower Greensand.  England | rhax (smooth),  sphere (smooth),  (drawings) | abundant | - 137 x 90  - 233 | ? | ? | *Rhaxella sorbyana*  *Rhaxelloides sphaerica*? | Hinde (1885) |
| Albian,  Early Cretaceous  (113-100.5) | Upper Greensand,  England | rhax (smooth),  sphere (smooth),  (drawings) | abundant | ? | ? | ? | *Rhaxella sorbyana*  *Rhaxelloides sphaerica*? | Carter (1871) |
| Santonian/Campanian boundary  Late Cretaceous,  (83.6) | Eastern slope of the Northern Urals, Russia | sterrasters  (SEM, smooth rosettes?) | ? | ~122-163  (measured from plate II & III) | ? | ? | *Geodia* sp. | Vishnevskaya et al. (2009) |
| Late Cretaceous | Malpaso, Chiapas, Mexico | 1) sterraster (spherical)  2) sterraster | not abundant | 1) 80-170  2) 100-140 x 60-100 | ? | ? | *Rhaxelloides sphaerica*  *Rhaxelloides cilindricas* | Trejo (1967) |
| Campanian,  Late Cretaceous  (83.6-72.1) | Northern Germany,  on hexact fossil *Coeloptychium* | aspidaster: flat, ellipsoid, spiny surface,  (radial structure) | ? | 80-150 x 60-100 | ? | ? | *Erylus* sp. | Zittel (1876) |
| rhax,  sterrasters (spherical)  (no radial structure),  spherasters | ? | ? | ? | ? | *Rhaxella sorbyana*  *Rhaxelloides sphaerica*? |
| Lower Campanian,  Late Cretaceous  (83.6-72.1) | Zbyczyce, Poland | sterrasters  (optical microscope, no hilum visible) | abundant | 90-195 x 90-150 | ? | ? | *~~Geodia~~* ~~sp.~~  *Stelletta* sp.?  (the *Geodia* sp. whole specimen is dubious and probably due to sterraster contamination (Wiedenmeyer, 1994; E. Swierczewska Gladysz, pers. comm.) | Hurcewicz (1966) |
| Campanian,  Late Cretaceous  (83.6-72.1) | Oberg (N Germany) | rhax,  sterrasters  (optical microscope) | ? | ? | ? | ? | *Rhaxella sorbyana*  *Rhaxelloides sphaerica*? | Schrammen (1924, p. 41, pl. VII) |
| Lower Campanian,  Late Cretaceous  (83.6) | Höver (N Germany) | selenaster (SEM, surface visible) | ? | 120-150 x 75-90 | ? | ? | ~~Geodiidae~~  *Placospongia* sp. | Gruber & Reitner (1991) |
| Lower Maastritchian  Late Cretaceous  (72.1-66.0) | Trimingham Chalk, Trimingham beach, Norfolk, UK | sphere, (smooth but hilum present)  (drawing) | abundant | 72-290 | ? | ? | *Geodites cretaceus*  ?Geodiidae | Sollas (1880) |
| Danian,  Paleocene  (66.0-61.7) | Porters Creek Formation, Sumter County, Alabama | sterrasters, spherical to subspherical  (SEM, no rosettes visible) | abundant | 180-200  (min: 105; max: 255) | clinoptilolite | offshore; calcareous claystone | *~~Geodia~~* ~~sp.~~  Geodiidae | Rigby & Smith (1992) |
| Late Paleocene to early Eocene | Landen Formation,  Belgium | rhax,  sterrasters  (SEM, no rosettes visible, radial structure) | dominant | 105-255 | opal-CT | ? | *~~Geodia~~* ~~sp.~~  Geodiidae | Geyter & Willems (1982)  Pastiels (1948) |
| Bartonian,  Middle Eocene  (41.2-37.8) | SW side of Mt. Duello, NE Italy | Sterrasters, elliptic to spherical (SEM, very good preservation, rosettes, radial structure, common hollow center)  aspidasters,  selenasters  (elliptic to bean-shaped) | dominant | 107-*180*-257  116-248  118-120 (measured from fig. 6) | opal-A, opal-C, opal-CT,  clinoptilolite | transgressive rocky shore, photic zone | *Geodia* sp.  *Erylus* sp.  *Placospongia* sp. | Frisone et al. (2014) |
| Bartonian,  Middle Eocene  (41.2-37.8) | Castle Hayne Formation, North Carolina, U.S.A. | Whole *Geodia*.  (sterrasters, no rosettes,  with hilum 37.5 µm)  (SEM) | Abundant specimens + loose sterrasters also very abundant in the matrix. | 200-250 | ? | Near-shore facies | *Geodia harmatuki* sp. nov. | Finks et al. (2011) |
| Late Eocene | Deep Lead, Princess Royal Township, Western Australia | Sterrasters (hilum)  (drawing) | abundant | 70-90 x 37-63 | ? | ? | Geodiidae | Hinde (1910) |
| Early Runangan, Late Eocene  (35) | Oamaru deposit,  New Zealand | Sterrasters (hilum, rosettes),  aspidasters  (drawing) | abundant | 95-121 | ? | ? | *Geodia* sp.  *Erylus* sp. | Hinde & Holmes (1892) |
| Priabonian,  Late Eocene  (37.8-33.9) | SW Australia | Sterrasters (some with smooth rosettes), selenasters  (SEM) | abundant | - 78-258  - 60-90 | opaline silica | quiet sea floor setting, below the wave base, occasionally disrupted by storm waves, 50-100 m depth | *Geodia* sp.  *Placospongia* sp. | Lukowiak (2015) |
| Priabonian,  Late Eocene  (37.8-33.9) | Pallinup Formation, Fitzgerald Member, Southern Australia, Hamersley River section, | Whole sponge  (SEM of sterrasters, rosettes are gone) | one specimen | 150-350 x 80-250 | opaline silica | Shallow-water nearshore environment | *Geodia hopetouni* sp. nov. | Lukowiak and Pisera (2016) |
| Late Eocene | South-Central Ukraine | aspidasters  (drawing) | ? | 115 x 92 | ? | ? | *Erylus* sp. | Lukowiak et al. (2019) |
| Middle to Late Eocene | South-Central Ukraine | sterrasters,  selenasters  (drawings) | ? | 80-150 x 80 | ? | ? | Geodiidae  *Placospongia* sp. | Lukowiak et al. (2019) |
| Lower Oligocene to Pleistocene  (33.9-1.8) | southern Viking Graben,  Northern North Sea | No illustrations | ? | ? | ? | ? | *Geodia* sp. | Eidvin & Rundberg (2007) |
| Karpatian,  Early Miocene  (16) | Carpathian Foredeep, Moravia | sterrasters, (hilum, some with warty rosettes, radial structure, hollow center). (SEM) | dominant (71.2%) | ? | ? | deep | Geodiidae  *+ Geodia* sp. from the Depressiogeodia+Cydonium clade | Říha (1982, 1987), Pisera & Hladilová (2003) |
| Middle Miocene  16 Ma | Cairo Production Company Mine, Thomas County, Georgia, USA | selenasters  (SEM) | ? | ? | ? | ? | *Placospongia* sp.  (according to Rützler & MacIntyre (1978)) | Weaver & Beck (1977) |
| Upper Miocene to Pleistocene  (11-120 000 y) | Western Wellington Province, NZ | sterrasters  (optical microscope, rosettes, some with radial structure, hollow center) | ? | 120-300 x  100-200 | some still with silica | ? | Geodiidae  *Geodia* sp. | Rich (1958) |
| Middle Eocene to the Lower Oligocene  (45-30) | Radiolarian beds,  Chalk deposit, Barbados | ? | ? | ? | ? | ? | *Erylus* sp. | Bury (1862) |
| Mid-Early Miocene  (21.8–17.6) | Dos Bocas Formation, Ecuador | 1) selenasters 2) sterrasters  (optical microscope, rosettes visible) | abundant | 1) 116x75  2) 80-120 x 70-90 | ? | Shallow reef area (<25 m) | *Geodia ~~neptuni~~*  *Geodia* sp.  *Placospongia ~~carinata~~*  *Placopongia* sp.  *~~Conciliaspongia~~ rarus* sp. nov.  *Geodia rarus* comb. nov. | Robinson & Haslett (1995) |
| Late Burdigalian  Early Miocene  (16) | Vienna Basin, Slovakia | sterrasters  (SEM, rosettes visible) | ? | >100 µm | ? | bathyal | Geodiidae  *+ Geodia* sp. | Lukowiak et al. (2014) |
| Middle Miocene  (17) | Blake-Bahama Basin, site 391 | sterrasters,  selenasters  (optical microcope) | ? | ? | ? | ? | Geodiidae  *Placospongia* sp. | Bukry et al. (1978) |
| Middle Serravallian  Miocene  (13) | Mem Moniz marls, Algarve, Portugal | Sterrasters + aspidasters  (SEM, rosettes) | dominant | ? | ? | ~100 m | Geodiidae  *Erylus* sp.  *+ Geodia* sp. | Pisera et al. (2006) |
| Late Miocene  (9.9-8) | Cappella Montei Alessandria, Italy | sterrasters  (SEM, some with radial structure, hollow center,  rosettes visible) | abundant | 108-206 x 98-177 | ? | Temperate shallow waters | *Geodia* sp.  + *Caminus/Pachymatisma* sp. | Bonci et al. (1997) |
| Tortonian,  Late Miocene  (8-7.2) | Ulea, Southern Spain | Whole sponge  (no SEM) | 4 specimens | 250 | Opal, silica | bathyal | *Geodia avicula* sp. nov. | Brimaud & Vachard (1986) |
| Late Miocene-Pliocene  (~6-3) | Somachi Formation, Kikai-Jima, Japan | sterrasters (optical microscope) | ? | 120-150 x 80 | silica | ? | *Hataina ovata* sp. nov.  (radiolarian)  *Geodia ovata comb. nov.* | Huang (1967)  Inoue & Iwasaki (1975) |
| Miocene-Recent | Sedili River mud, West Malaysia | sterrasters  (SEM, some with radial structure, hollow center,  rosettes visible) | ? | <160 | opal | 1 m depth | *~~Silicosphaera~~ asteroderma* sp. nov.  *Geodia asteroderma* comb. nov. | Hugues (1985) |

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