geosciences

MDPI

Review

Review of the Fossil Heritage Potential of Shenzhen (Guangdong, China): A Promising Area for Palaeontological Research

David Marius Kroeck [1,*], Yanxin Gong [2], He Chen [1], Lan Li [1] and Tong Bao [1,*]

[1] State Key Laboratory of Biocontrol, School of Ecology, Shenzhen Campus of Sun Yat-sen University, Shenzhen 518107, China; chenhe6@mail.sysu.edu.cn (H.C.); lilan39@mail.sysu.edu.cn (L.L.)
[2] Shenzhen Museum, Shenzhen 518026, China; gyx592779474@163.com
* Correspondence: kroeck@mail.sysu.edu.cn (D.M.K.); baot3@mail.sysu.edu.cn (T.B.)

Abstract: The area of the city of Shenzhen at the Pearl River Delta in Guangdong Province, China, comprises rocks that preserve, with few interruptions, around 1.8 billion years of geological history. However, to date, only few scientific studies within a palaeontological context have been conducted on the sediment rocks in Shenzhen. Herein, the fossil record and heritage potential of Shenzhen is reviewed. The few existing previous investigations revealed a rich terrestrial and marine fossil record and show the great potential of this area for future palaeontological research, particularly on the upper Palaeozoic and Mesozoic strata: Carboniferous successions show plant remains and a diverse benthic marine fauna; fossils from Upper Triassic–Middle Jurassic sediment rocks provide important data for terrestrial and marine palaeoecosystems of this time; and the discovery of dinosaur nests in the Upper Cretaceous strata complements the previously known distribution of dinosaurs in South China. Additionally, micropalaeontological and palynological data from the upper Palaeozoic as well as Cenozoic successions in Shenzhen reveal diverse assemblages of foraminifera, ostracods, diatoms, and sporomorphs. Moreover, fossil finds in equivalent rocks in adjacent areas indicate great potential for the units in the Shenzhen area, in which, so far, no fossils have been found.

Keywords: geoheritage; fossil record; palaeontology; South China; Cathaysia

Citation: Kroeck, D.M.; Gong, Y.; Chen, H.; Li, L.; Bao, T. Review of the Fossil Heritage Potential of Shenzhen (Guangdong, China): A Promising Area for Palaeontological Research. *Geosciences* **2024**, *14*, 316. https://doi.org/10.3390/geosciences14120316

Academic Editor: Karoly Nemeth

Received: 27 September 2024
Revised: 17 November 2024
Accepted: 19 November 2024
Published: 22 November 2024

1. Introduction

The geological and palaeontological heritage of a region is an important aspect in the promotion of science and tourism. The term "geoheritage" describes the non-living part of the natural heritage, with a special focus on elements of particular geological value [1]. Palaeontological features, i.e., any traces of past life, can play a major role in the geoheritage of a region. In the late 20th and early 21st centuries, interest in geoheritage research increased significantly, and many countries started initiatives for geoconservation [2]. Geoheritage issues have also become part of the agendas of the International Union for Conservation of Nature (IUCN), which recognized the importance of geological features as integral parts of nature [3,4], and UNESCO, which established the International Geoscience and Geoparks Programme [2]. To date, 213 areas around the world are designated as UNESCO Global Geoparks. Geosites, i.e., localities of particular geological interest [5], bear scientific, scenic, cultural, and economic value (e.g., [6,7]) and therefore deserve protection from natural degradation and human activities [8,9]. Geosites may comprise the preserved record of millions of years of geological history, often documenting the evolution of life and natural environments, and thus are of great educational and scientific value [9]. Their attractiveness to tourists and their geoscientific value are dependent on the respective conversation measures. Furthermore, the benefits, i.e., environmental, community, and economic value, need to outweigh any adverse impacts to achieve optimal and sustainable geotourism [10]. Research plays an important role in geoheritage and geoconservation assessment and improvement. Geoscientists, together with experts in resource management and policy makers, assess the value and geoconservation needs of a geological feature [11].

Owing to multiple periods of complex tectonomagmatic as well as tectonosedimentary activity, the Shenzhen area is characterized by a diverse geology. Previous research and geological surveys in Shenzhen revealed a rich fossil record, including invertebrate and vertebrate fossils, microfossils, palynomorphs, and plant remains, of both marine and terrestrial ecosystems, indicating great potential for palaeontological studies. However, to date, only few scientific publications on the fossil strata of this area exist. Indeed, most knowledge about the fossil content of the regional rock formations comes from several geological surveys performed in this area since the 1960s, particularly by the Guangdong Provincial Bureau of Geology (GPBG).

After the pioneering work by Zhu Tinghu in 1932, who inspected the geology of the Shenzhen area (the former Dongguan and Bao'an counties) [12], the GPBG conducted a large-scale geological and mineralogical survey in the region around the Pearl River Estuary between 1959 and 1962 to produce 1:200,000 maps [13]. These works were then included by the GPBG to create a 1:500,000 geological map of Guangdong Province between 1974 and 1979. A detailed comprehensive investigation of the local geology of Shekou Peninsula, Nantou, Tuenyang, and Dapeng Peninsula was carried out between 1979 and 1981 within the context of selecting a site for a Nuclear Power Plant, which resulted, among others, in a 1:50,000 regional geological survey report by the GPBG. The Second Hydrological Geology Brigade of the Guangdong Geological Bureau published in 1981 a 1:200,000 engineering geology map and report for the Pearl River Estuary. In 1982, the Shenzhen Geological Bureau (SGB) conducted a geological survey in Luohu District, compiling a 1:10,000 geological map, including a report, for this area of Shenzhen. The SGB also presented geological maps and tables, including fossil records, for the Shenzhen area in the context of a visit to Hong Kong in 1984, organized by the Geological Society of Hong Kong, and published in the society's newsletter [14]. A comprehensive study of the geology of the Shenzhen Special Economic Zone was carried out in the years 1981 and 1985 to produce a 1:50,000 geological map and report [15]. Parts of the northwestern area of Shenzhen were included in a geological survey of Dalangzhen, Dongguan, and Shajin, Bao'an, between 1996 and 1998 by the Guangdong Geological and Mineral Exploration and Development Bureau (GGMEDB), which published the results in a 1:50,000 geological map and the associated report [16]. Between 2000 and 2002, the Guangdong Provincial Institute of Geological Survey conducted a geological survey of Hong Kong and Jiangmen, including the areas of Shenzhen, resulting in 1:250,000 maps (sheets F49C002004 Jiamen and F50C002001 Hong Kong) and reports [17,18]. An extensive account of the Geology of the Shenzhen area, largely based on these previous surveys, was compiled and published by the Compiling Group of Shenzhen Geology in 2009 [19]. Gong and Zhang [20] provided an account of the geological heritage sites in Shenzhen, summarizing the efforts of geoheritage protection, and offered perspectives and suggestions for more efficient management in the future.

While most studies on the Palaeozoic biota from South China focused on the epicontinental sea between the Yangtze and Cathaysia plates, the position of the Shenzhen area at the peripheral margin of the palaeocontinent (Figure 1) makes research on its fossil record particularly interesting. However, palaeontological publications based on successions in the Shenzhen area are so far rare and have mostly been on the Jurassic strata of Dapeng Peninsula, with studies focusing on bivalves [21] and land plants [22]. The chance discovery of Late Cretaceous dinosaur eggs led to further research [23].

Here, we provide a synthesis of the palaeontological research in the Shenzhen region in Guangdong, China, to date, and a comprehensive review of the fossil record of this area and assess its value for future studies and tourism. Owing to previous geological surveys focusing on different geographical regions, with many including an outdated stratigraphic scheme, the lithostratigraphy in the Shenzhen area is partly ambiguous and not always correlatable. In this paper, we follow the scheme used in [24] (Figure 2).

2. Geographic and Geological Background

2.1. Palaeogeographic History

The city of Shenzhen is located in the eastern regions of the Pearl River Estuary in southern Guangdong Province, just north of Hong Kong. Geotectonically, this area belongs to the Cathaysia Block, the southeastern structural part of the South China Block. The South China Craton formed during the Neoproterozoic by the collision of the Yangtze and Cathaysia blocks (e.g., [25–27]). Cathaysia itself consists of two terranes, with distinct geological histories. The Shenzhen area is located in the suture zone of these terranes, with the northwestern parts belonging to West (or 'interior') Cathaysia, and the southeastern parts to East (or 'coastal') Cathaysia [28–30]. The two terranes are separated by the Zhenghe-Dabu Fault [28] or the Northwest Fujian Fault [29,30].

While its early Palaeozoic position, either attached to or separated from Gondwana, is still debated, South China was situated in low latitudes in the vicinity of Gondwana during this time (see [31,32], and references therein). In the Lower Devonian, with an episode of rifting associated with the opening of the East Palaeotethys, the South China Plate began to drift northward as an isolated plate [32–34] (Figure 1A,B).

During the late Palaeozoic and Mesozoic, the continental terranes that form today's Southeast and East Asia progressively collided and amalgamated. Most importantly, between the Carboniferous and Triassic, South China merged with the Indochina, East Malaya and Sibumasu plates, and in the Late Triassic to Early Jurassic, with North China (e.g., [31,33–35]) (Figure 1C). With the amalgamation of most of the major terranes by the end of the Cretaceous, proto-Southeast Asia had formed [35] (Figure 1D).

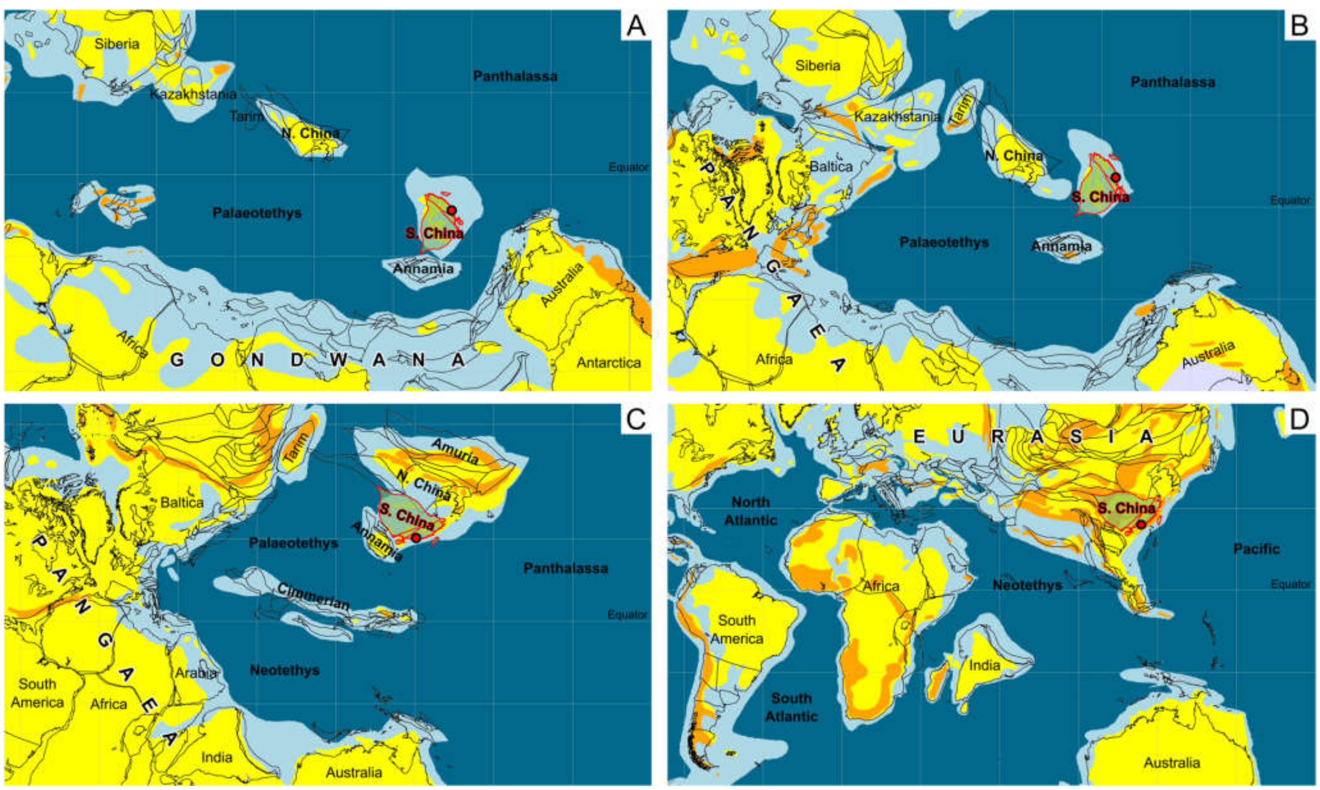

Figure 1. Palaeogeographic maps showing the position of the South China Plate and the Shenzhen area (red dot) through time. (**A**) Early Devonian (396 Ma); (**B**) Early Carboniferous (328 Ma); (**C**)

Late Triassic (232 Ma); (**D**) Late Cretaceous (76 Ma). Reconstructions based on [36,37]; created with Gplates [38]. Mercator projection.

2.2. Tectonosedimentary History

In the late Neoproterozoic (Sinian) and early Palaeozoic, extensive siliciclastic, particularly turbiditic, successions formed on West Cathaysia. During the early Palaeozoic, the Proterozoic basement of Cathaysia was subjected to large-scale tectonism and magmatism in the "Wuyi-Yunkai orogeny" (also termed "Kwangsian orogeny"), which formed the South China Fold Belt (e.g., [39,40]). This orogeny led to an absence of Late Ordovician and Silurian sedimentation, which is reflected in a prominent angular unconformity between the upper Palaeozoic deposits and the strongly deformed early Palaeozoic strata (e.g., [39,41–43]).

A major transgression beginning in the Early Devonian is signaled by the restart of deposition across the western parts of the Cathaysia Block, with the northeastern to southeastern areas comprising the Cathaysia Old Land [44]. The sea advanced further in the Middle Devonian and reached the Shenzhen area by the Givetian, with the establishment of coastal shallow marine deposition in this region [24,44].

Another major tectonic event related to the amalgamation of South China with the Indochina Block during the Late Permian and Triassic ("Indosinian Event") and the nearly coeval collision-orogeny between South China and North China led to the formation of postorogenic sedimentary basins in South China [39,45–53]. One of these structures is the East Guangdong Basin at the southeastern margin of the South China Block, to which the Shenzhen area belongs. With the subduction of the Palaeo-Pacific Plate beneath the South China Plate, the region was subjected to further tectonic activities as well as magmatism during the Jurassic and Cretaceous interval ("Yanshanian Orogeny") (e.g., [39,54,55]). As a result of tectonic uplift during these events, as well as two large-scale marine transgressions in the southeastern parts of South China in the Late Triassic to Early Jurassic interval, great amounts of sediments were deposited in the East Guangdong Basin [53,56–58]. While the Upper Triassic and Lower Jurassic successions indicate a shallow marine to deltaic depositional environment [53], the milieu changed to more terrestrial conditions in the Middle Jurassic, with predominantly fluvial and lacustrine sediments [57].

With the subduction of the Palaeopacific, the Jurassic–Cretaceous in South China was also characterized by an intracontinental extensional regime, which led to the widespread formation of numerous extensional basins, half-grabens, and domes (e.g., [59–61]), as well as widespread magmatism, e.g., in East Cathaysia in the southeastern coastal parts of the South China Block (e.g., [53,55,61]). Partly belonging to the Southeastern China Coastal Late Mesozoic Volcanic Belt, the Shenzhen area was also subjected to extensive volcanism during this time [24,55]. The extensional basins and half-grabens were filled with syntectonic sediments, volcanoclastics, and rhyolitic lava during the Early Cretaceous and by red-colored sediments in the Late Cretaceous and Palaeogene in a variety of, mostly terrestrial, depositional environments (e.g., [59,61]).

During the Quaternary, a series of small-scale basins and valleys developed along the NE–SW-trending Shenzhen Fault Zone: The Shenzhen Bay Depression, Shenzhen Reservoir Valley, and the Liantang, Henggang, Xikeng, Guanyinbu, Longgang, Pingshan, and Tamsui Basins [62]. The development of these landforms was not only controlled by the pre-existing fault system, but also by structural lithological combinations, differential erosion, and karstification. Within these structures, Quaternary deposits led to planations and multi-level river terraces. While the early and middle Pleistocene sedimentation was rather limited, the Upper Pleistocene deposits, mostly fluvial sediments (Pingshan Formation), are well developed. Holocene sedimentation was mainly restricted to the modern river valleys and formed river floodplains and lower terraces [62,63].

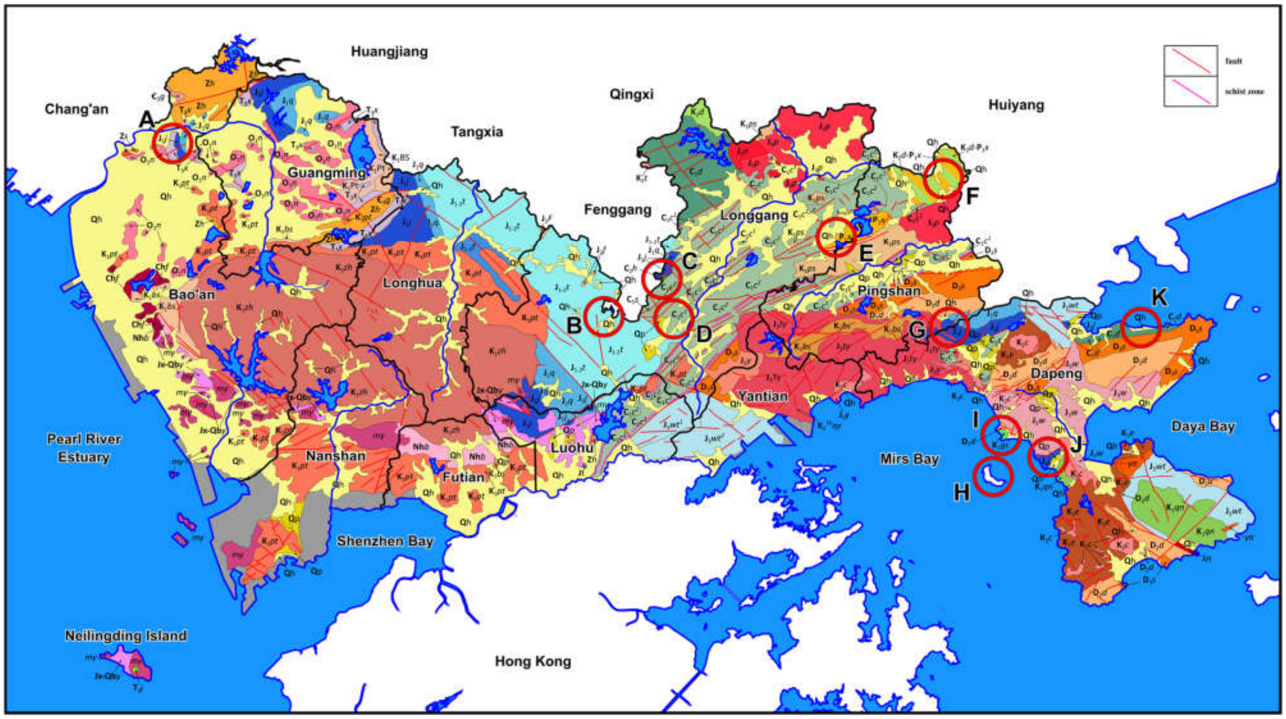

Figure 2. Geological map of Shenzhen. For a legend, see Figure 2. Known fossil localities (red circles): (**A**) Hongqiaotou; (**B**) Bainikeng-Yantian area; (**C**) He'ao; (**D**) Henggang; (**E**) Tongle; (**F**) Kengzi; (**G**) Pingtou Ridge-Kuiyong area; (**H**) Tung Ping Chau; (**I**) Xiasha; (**J**) Nan'ao-Shuitousha; (**K**) Hengshan-Tianliao area. Geology after [24]; administrative map according to Shenzhen Municipal Bureau of Planning and Natural Resources [64].

3. Materials and Methods

3.1. Data Gathering

We conducted a detailed census of fossil data of the Shenzhen area based on a comprehensive review of the relevant literature, i.e., all published research papers, geological surveys, and conference abstracts on this matter, in order to synthesize the palaeontological knowledge of this region and review its palaeontological heritage and history. Geological survey reports, including geological maps and stratigraphic profiles, were provided by the National Geological Archives of China (NGA). In total, 14 stratigraphic units and eleven fossil localities with potential for palaeontological research were identified (Figures 2 and 3).

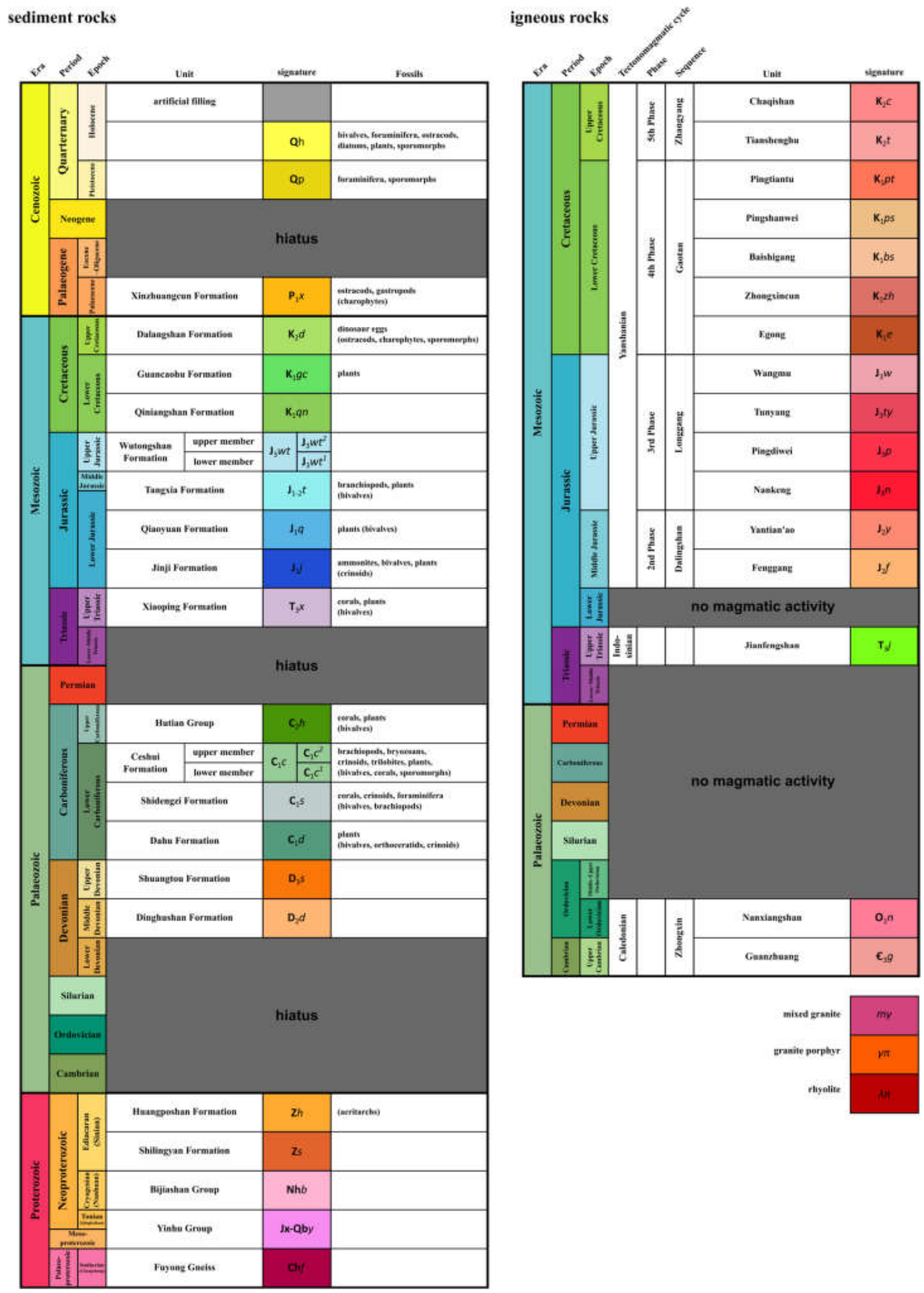

Figure 3. Stratigraphy of Shenzhen. Fossils in brackets: recorded in the unit in adjacent areas but, so far, not in Shenzhen. After [24].

3.2. Analytical Procedures

Based on the literature, all known fossil taxa reported from each locality and stratigraphic unit were categorized and summarized (Figure 3; Tables 1–3). A database for all fossil taxa found in Shenzhen was created, including the originally designated age, the corrected or updated age, and the locality where the fossils were found. Based on the most recent literature, the stratigraphy for all localities was updated and unified, and the palaeontological history of the Shenzhen area was reconstructed in the context of the regional geotectonic evolution. Furthermore, outdated and inaccurate taxonomies were corrected based on published taxonomic revisions. The revised plant taxa include *Paripteris gigantea*, which was originally named *Neuropteris gigantea*, different species of *Rhodeopteridium* originally assigned to the genus *Rhodea*, and some of the fossils of *Pterophyllum* that were originally identified as *Ctenophyllum*. *Ulmoideipites minor* was corrected to *Ulmipollenites minor*. Within bivalves, occurrences assigned to *Parainoceramus* were renamed *Parainoceramya*, the genus *Plagiostoma* was changed to a sub-genus of *Lima*, the sub-species *Palaeoneilo hulukouensis jinjiensis* is now considered a separate species *Palaeoneilo jinjiensis*, *Astarte heberti* was included in its senior synonym *Astarte consobrina*, and *Teinonuculana guangdongensis* was transferred to the genus *Ryderia*.

4. Overview of the Fossil Record of Shenzhen

Known occurrences of fossil groups for each stratigraphical unit in Shenzhen are provided in Figure 3; complete lists of recorded taxa, including their respective location and stratigraphical unit, are listed in Tables 1–3 (Table 1: animals; Table 2: plants; Table 3: microfossils).

4.1. Precambrian Record

Precambrian rocks are mainly found in the hills in the western parts of Shenzhen. While no palaeontological studies have been conducted in these strata in Shenzhen, organic-walled microfossils have been described in adjacent areas in the Neoproterozoic Huangposhan Formation, which is distributed in the northern part of Bao'an (Yanchuan Village area), and southern Guangming District (Ejing Reservoir area) (Figure 2). Palynological analyses of carbonaceous shales of this unit at Fei'e Mountain in Chang'an, north of Shajing (Bao'an) revealed a rich acritarch flora, including *Laminarites*, *Leiopsosphosphaera*, *Trachysphaeridium*, *Asperatopsophosphaera*, *Pseudozonosphaera*, *Zonosphaeridium*, *Trematosphaeridium*, *Leiofusa*, *Synsphaeridium*, *Lignum*, *Polyperata*, *Triangumorpha,* and *Macroptycha* [16,24]. This microfossil assemblage allowed an assignment of the Huangposhan Formation to the Sinian (Ediacaran) [16,24]. Further acritarch assemblages were recovered from the Sinian Laohutan Formation in Jiangmen, west of Shenzhen [17].

4.2. Palaeozoic Record

4.2.1. Cambrian–Silurian

Early Palaeozoic sediment rocks are not exposed in the Shenzhen area. However, Cambrian to Ordovician strata crop out in the area northeast of Shenzhen, in Huizhou, as well as southwest, in Jiangmen. There, siliciclastic sediments of the Middle Cambrian Gaotan Formation and the Upper Cambrian Shuishi Formation revealed rich acritarch and prasinophyte flora as well as inarticulate brachiopods and sponge spicules [13,17,18,65]. Lower Ordovician deposits (Xinchang and Hushan Formations) in the Huizhou, Heyuan, and Jiangmen areas contained graptolites [13,17]. Silurian sediment rocks have not been described in Shenzhen or adjacent areas since the area was exposed due to the Wuyi-Yunkai orogeny, causing a significant gap in the sediment record (see Section 2.2).

4.2.2. Devonian

The Middle and Upper Palaeozoic (Devonian–Carboniferous) strata are widespread in the Shenzhen area [24] (Figure 2). Middle to Upper Devonian rocks (Dinghushan and Shuangtou Formations) are exposed in the eastern parts of Shenzhen, on Dapeng Peninsula (e.g., Paiya Mountain), in the Pingshan area (Dashanpo and Chi'ao Reservoir area), and in northwestern Yantian District/southeastern Longgang District. While, so far, no fossils have been observed in these units in Shenzhen, rich marine and terrestrial fossil assemblages were recorded in equivalent strata in other places, i.e., the Chunwan and Maozifeng Formations in Jiangmen and Huizhou, the Bluff Head Formation in Hong Kong, and the Upper Guitou Subgroup in northern Guangdong:

In the Bluff Head (=Wong Chuk Kok Tsui) Formation along the northern coast of the Tolo Channel in Hong Kong, ca. 16 km southwest from Dapeng Peninsula, a marine fauna comprising various taxa of bivalves, e.g., *Deceptrix*, *Edmontia*, *Eoschizodus*, *Goniophora*, *Nuculoidea*, *Orthonota*, *Pseudonuculana*, *Sanguinoilites*, and *Spathella*, several fishes, including *Hongkongichthys* and *Moythomasia,* as well asan undefined coelacanthiform, gastropods, and crinoids were recovered [18]. Micropalaeontological analyses showed numerous taxa of ostracods, including several species of the genera *Paramoelleritia* and *Sinoleperdidia* (*Pseudobriartina*) within this formation [18]. Furthermore, the strata also contained land plant fossils; *Leptophloeum*, *Taeniocrada*, *Protopteridium*, *Lepidodendropsis*, *Pseudosporochnus*, *Dimeripteris,* and *Glyptoarmussia* were observed [18].

Deltaic to shallow marine deposits of the Upper Devonian Chunwan Formation in Jiangmen, southwest of Shenzhen, contain fossils of antiarch placoderms, including *Bothriolepis*, as well as brachiopods, such as *Cyrospirifer*, and land plant remains assigned to the taxa *Sphenopteris*, *Carpolithus*, *Archaeopteris*, *Eolepidodendron*, *Lepidostrobus*, and *Stigmaria* [17]. In Huidong and Huizhou, northeast of Shenzhen, this formation showed a diverse miospore flora, including *Leiotriletes*, *Calamospora*, *Punctatisporites*, *Retusotriletes*, *Apiculiretusispora*, *Granulatisporites*, *Raistrickia*, *Verrucosisporites*, *Biornatispora*, *Anurospora*, *Ancyrospora*, *Nymenozonotriletes*, *Grandispora*, *Retispora,* and *Laevigatosporites* [18]. The uncertain identification of *Retispora lepidophyta* may indicate a Latest Famennian age of this assemblage, however, further palynological studies are needed for more precise dating of these layers.

The overlying Upper Devonian to Lower Carboniferous Maozifeng Formation in Huizhou contains brachiopods of the genus *Eochoristites*, crinoids belonging to *Cyclocyclicus*, and plant remains assigned to *Stigmaria* and *Sublepidodendron* [13]. Further brachiopods of the genera *Yunnanella*, *Lingula*, *Cryptospirifer*, *Hunnanella*, and *Hunnanospirifer*, as well as the bivalves *Leptodesma* and *Orthonota,* and plant remains of *Hamatophyton* were found in tidal flat sediments of this unit in Jiangmen [17,18].

The Upper Guitou Subgroup in the Shaoguan area in northern Guangdong revealed fish fossils of the genus *Bothriolepis* as well as plant remains assigned to *Protolepidodendron* and *Psilophyton* [13].

4.2.3. Carboniferous

The Carboniferous successions in Shenzhen, which are widespread in the central, eastern, and northeastern parts (Luohu, Longgang, Pingshan, and Dapeng Districts; Figure 2), are locally rich in fossils. Early Carboniferous marine and terrestrial biota have been recorded in the Dahu, Shidengzi and Ceshui Formations in the Shenzhen area, as well as in the Changlai Formation just northwest of Longgang in Dongguan. Late Carboniferous fossils are found in the sporadically outcropping rocks of the Hutian Group.

Strata of restricted to open marine platform facies exposed in Fenggang Town, Dongguan, which were assigned to the Lower Carboniferous Changlai (formerly known as 'Changchi') Formation, contained abundant ostracods, including the genera *Shishaella*, *Paraparchites*, *Bairdia*, *Bairdiocypris,* and *Mierocheilinella* [18].

Sediments of the Lower Carboniferous Dahu Formation are distributed in the northern Paiya Mountain area in Dapeng New District and in the northern parts of Longgang (Qinglinjing Reservoir). Terrestrial plant fossils recovered from the northern coastal slopes of Paiya Mountain (between Tianliao Xia and Hengshan Mountain Corner, Figure 2K) showed an early Carboniferous flora comprising large lycophytes, Equisetales, and ferns; *Sublepidodendron*, *Stigmaria*, *Rhodeopteridium* (as *Rhodea*), and *Archaeocalamites* were identified here [15,24] (originally assigned to the Shuangtou Fm. in [15]). Fossils of *Rhodeopteridium* (as *Rhodea*) were also recorded in rocks of the Dahu Formation in northern Longgang [24]. Crinoid stems were reported in sediments of littoral to neritic facies assigned to the Dasaiba Formation, which corresponds to the Dahu Formation, in the area of southern Dongguan and northern Longgang [18]. This unit also contained abundant bivalves (*Eupera*), brachiopods (*Fusella*, *Pleuropugnoides*), orthoceratoid nautiloids (*Michelinoceras*(?)), crinoids (*Cyclocyclicus*), and plant remains in areas west of the Pearl River Delta (Jiangmen and Foshan) [17]. The sedimentology and fossil content of the Dahu Formation indicate a deposition in a coastal (litoral to shallow marine) milieu [17,24].

Strata of the overlying Shidengzi Formation (which was previously assigned to the Ceshui Group) are exposed sporadically near He'ao, Longgang (Figure 2C), from where fossils of a rich shallow marine benthic fauna were reported, including rugose (*Arachnolasma*, *Aulina*, *Kueichouphyllum*, *Lithostrotion*, and *Lophophyllum*(?)) and tabulate corals (*Syringopora*), crinoids, and foraminifers of the order Fusulinata (e.g., *Endothyra*, *Eostafella*, *Eotuberitina*, and *Palaeotextularia*) [14,15,24]. Similar assemblages were recorded within the Shidengzi Formation in other localities in Guangdong Province [17,18,66], including Jiangmen and Foshan, where corals (*Diphyphyllum*, *Caninia*, *Heterocaninia*, *Kueichouphyllum*, *Lithostrotion*, *Nezaphrentites*, *Syringopora*, and *Zaphrentites*) and brachiopods (*Chonetes* and *Neoperioriodus*) were recovered from this unit [17]. Additionally, bivalves of the genus *Dielyoclostus* were found in Huizhou [18].

Alternating marine and terrestrial sediments of the successive Ceshui Formation (Viséan) are widely found in Luohu (e.g., Liantang and Hengpailing) and Longgang (e.g., He'ao and Henggang), but stretch to other localities, such as Hong Kong, Huiyang in Huizhou, Dongguan, Foshan, and Jiangmen. This unit contained a rich fossil marine fauna, including bivalves, brachiopods, corals, and foraminifera, as well as land plants, as observed in various localities in Guangdong Province [17,18,66]. Limestones of the Ceshui Formation in Longgang (Henggang and He'ao; Figure 2C,D), Shenzhen, and in Qingxi, Dongguang, showed records of brachiopods (*Chonetes*, *Choristites*, *Echinoconchus*, *Kansuella,* and *Schuchertella*), crinoids (*Cyclocyclicus*), trilobites (*Phillipsia*), and fenestrate bryozoans, such as *Fenestella* [13–15,18,24]. Coal seams and plant fossils, including the enigmatic *Rhodeopteridium* and the seed ferns *Paripteris*, *Neuropteris,* and *Alethopteris* [14,15,18,24], mark horizons with a strong terrestrial influence. Brachiopods (*Athysis*, *Linoproductus*, and *Schuchertella*), tabulate corals (*Syringopora*), and plant remains (*Archaeocalamites* and *Rhodeopteridium*) were also found in Ceshui strata west of the Pearl River Estuary in localities in Foshan and Jiangmen [17]. Furthermore, carbonaceous mudstones of the Ceshui Formation showed a rich flora of terrestrial palynomorphs, with several species assigned to the genera *Acanthotriletes*, *Calamospora*, *Cingulizonates*, *Crassispora*, *Densosporites*, *Lophotriletes*, *Lycospora*, *Punnctatisporites*, *Leiotriletes*, *Cyclogranisporites*, *Triquitites*, and *Tripartites* [18].

The Ceshui Formation is overlain by shallow marine carbonate rocks of the Upper Carbonifeorus Hutian Group, which is exposed in a small area in He'ao, Longgang (Figure 2C). Here, crinoid stems and foraminifers of the genus *Quasifusulina* were found [15,24]. Several further taxa of fusulinacean foraminifera were recorded abundantly in the Hutian Formation in Kaiping, Jiangmen, west of the Pearl River Estuary, including *Aljutovella*, *Fusulina*, *Fusulinella*, *Triticites*, and *Schwagerina* [17]. The depositional environment has been interpreted as a restricted shallow marine platform [17,24].

4.2.4. Permian

Permian rocks have, so far, not been found in Shenzhen. However, middle Permian strata from the Tongziyan Formation on the island of Ma Shi Chau, Hong Kong, contained gastropods, brachiopods, bivalves, corals, crinoids, and other fossils [18]. In Kaiping, Jiangmen, abundant plant remains were found in the Tongziyan Formation [17].

4.3. Mesozoic Record

4.3.1. Triassic

The oldest Mesozoic deposits of the Shenzhen area comprise the coal-bearing clastic sediments of the Upper Triassic Xiaoping Formation, which is distributed in the Shajing and Gongming areas of Bao'an District (Figure 2). This unit comprises a complex succession that reflects a frequently changing palaeoenvironment, including sediments of fluvial–marine transition, shallow marine lagoon, and lacustrine-paludal facies [18,24]. Carbonaceous shales within the Xiaoping Formation in Hongqiaotou Village, Songgang, in the northwestern Shenzhen area (Figure 2A) revealed leaves of the taxa *Pterophyllum* (as

Ctenophyllum) and *Taeniopteris*, the former derived from Bennetittaleans and the latter possibly from cycads, ferns, or also Bennettitaleans, as well as remains from the Equisetalean *Neocalamites* and the ferns *Clathropteris* and *Phlebopteris* [16,17,24]. The strata also contained records of marine biota, as shown by the coral *Desmophyllum,* at the base of the formation in Hongqiaotou Village [16,17]. *Pterophyllum* and *Taeniopteris* have also been documented in Dalang and Shatangwei, Dongguan, just north of Shenzhen [18]. Particularly abundant and diverse plant assemblages within the Xiaoping Formation were described west and northwest of Shenzhen, in localities in Jiangmen, Foshan, and Guangzhou, including ferns (*Cladophlebis*, *Clathropteris*, *Danaeopsis*, *Dictyophyllum*, *Goeppertella*, *Pecopteris*, and *Thaumatopteris*), seed ferns (*Lepidopteris*, *Ptilozamites*, *Taeniopteris*, and *Thinnfeldia*), Bennettitaleans (*Anomozamites* and *Pterophyllum*), Equisetales (*Equisetites* and *Neocalamites*), cycadophytes (*Sinoctenis*), conifers (*Podocarpites* and *Podozamites*), ginkgophytes (*Baiera*), and the enigmatic *Nilssonia* [17]. Here, too, marine fossils were found, i.e., bivalves, including *Bakevelloides* and *Modiolus*, and corals of the genera *Desmophyllum* and *Glossophyllum* [17]. Northeast, in Huizhou, the Xiaoping Formation revealed fossils of plants, assigned to *Pterophyllum*, *Podozamites*, and *Equisetites*, and of bivalves, including *Myophoriopis*, *Pleuromya*, and *Volsella* [18].

4.3.2. Jurassic

The Lower Jurassic of the Shenzhen Region is characterized by fossiliferous successions showing a regressive interval from proximal marine facies with phases of continental intercarlations to fully continental sediments. The Jinji and Qiaoyuan Formations contain fossils of shallow marine fauna and terrestrial flora. The succeeding Tangxia Formation is composed of lacustrine sediments, with fossils of freshwater organisms and land plants.

The Lower Jurassic Jinji Formation (which equals the Lantang Group of older stratigraphic schemes and further inland) comprises shallow marine, partly coal-bearing, siliciclastic sediments. Rocks of this unit are widespread in Shenzhen (Figure 2), e.g., in the northern parts of Guangming (Liangtan and Tiekeng Reservoir area) and Longhua districts (Dashuikeng Reservoir area), in the western part of Luohu District (Yinhushan area), Longang District (Dayun Park area east of Fenggang), and in Dapeng New District (east of Chi'ao Reservoir and Shuitosha). Wang et al. [22] recovered and described a rich early Jurassic terrestrial flora within the Jinji succession exposed at the village of Shuitousha, northeast of Nan'ao on Dapeng Peninsula (Figure 2J). These fossils showed an ancient vegetation dominated by Bennettitaleans, with abundant Equisetales, ferns, cycads, and conifers. The assemblage thus is similar to that found in the Upper Triassic Xiaoping Formation. This first described Jurassic land plant fossil assemblage from Guangdong Province contained densely distributed and well-preserved pinnae and rachis connected leaves, as well as reproductive organs [22]. The Bennettitaleans were a globally distributed group of gymnosperms with high diversity in the Mesozoic that became extinct at the end of the Cretaceous. The assemblage on Dapeng Peninsula includes four genera of Bennettitaleans: *Otozamites*, *Williamsoniella*, *Ptilophyton*, and *Zamites*. Despite their frequent occurrence, their systematic position is still debated, and only few finds record their reproductive structures. Therefore, this find in Shenzhen provides valuable data for this important group of land plants and their palaeoenvironment. In conference presentations, Wang et al. [67,68] reported a new species of *Williamsonia* from the Shuitousha locality (Figure 2J) named after the city of Shenzhen, *W. shenzheniana*, which would be the first species of this genus described in China. However, this species remains, to date, a nomen nudum, as a valid description has yet to be published. Other taxa occurring in this assemblage are the Equisetaleans *Equisetites* and *Neocalamites*, the ferns *Dictyophyllum*, *Cladophlebis,* and *Clathropteris*, the cycad-like *Nilssonia*, and the conifers *Plagiophyllum*, *Elatocladus*, *Sphenolepis*, and *Taeniopteris* [22]. The discovered flora indicates a coastal swamp area in a warm, humid climate. Plant remains were also recorded in rocks of the Jinji Formation at

Pingtou Ridge near Xintang at the border between Pingshan and Dapeng Districts (Figure 2G). These fossils were assigned to the Equisetaleans *Equisetites* and *Neocalamites* [15].

Fossils of early Jurassic marine ecosystems, particularly ammonites and bivalves, have been recorded in the Jinji Formation as well, particularly in the lower parts (equaling the Yinpinshan and Shanglongshui Formations) [17,21,22]. In Shuitousha on Dapeng Peninsula (Figure 2J), several genera of bivalves, i.e., *Astarte*, *Cardinia*, *Entolium*, *Homomya*, *Luciniola*, *Mesomiltha*, *Parainoceramya*, *Protocardia*, *Pseudotrapezium*, and *Tracia*(?), have been identified, as well as the ammonite *Hongkongites hongkongesis* [15,21,22,24]. Huang [21] described several new bivalve species based on material from this section, including one named after Shenzhen: *Mesomiltha*(?) *shenzhenensis*. In the northwestern Daya Bay area (near Hengshan, Figure 2K), the lower Jinji Formation revealed another bivalve assemblage comprising the genera *Lima* (*Plagiostoma*), *Nuculana*, *Palaeoneilo*, *Radulonectites*, and *Teinonuculana*(?) [15,24]. The latter was also recorded at Pingtou Ridge (Figure 2G) [15]. The composition of these fauna indicates a proximal semi-restricted shallow marine environment during deposition [15,18,21,24]. Diverse marine fauna of ammonites, including *Agassiceras*, *Arietites*, *Arnioceras*, *Asteroceras*, *Coroniceras*, *Eparietites*, *Juraphyllites*, *Pseudaetomoceras*, *Psiloceras*, and *Sulciferites*, as well as bivalves, such as *Astarte*, *Chlamys*, *Cultriopsis*, *Fimbria*(?), *Hiatella*, *Leda*, *Liostrea*, *Loripes*, *Luciniola*, *Meleagrinella*, *Myophoria*, *Nuculana*, *Otapiria*, *Oxytoma*, *Palaeoneilo*, *Palaeonucula*, *Parainoceramya*, *Plagiostoma*, *Radulonectites*(?), *Teinonuculana*, *Tutcheria*, *Unicardium*, *Veteranella*, and *Yokoyamaina*, have been recorded in the Jinji Formation in other localities in Guangdong, including Huizhou and Jiangmen [13,17,18,69–71], as well as in equivalent strata in Hong Kong [72]. The fossil record indicates a Hettangian–Pliensbachian age [17,24,69].

Plant fossils were also found in the alternating terrestrial and marine sequences of the overlying Lower Jurassic Qiaoyuan Formation, which is distributed in Bao'an, Longgang, and Dapeng Peninsula (Figure 2). As with the Jinji Formation, fossils in the Qiaoyuan Formation have been found in the Shuitousha area (Figure 2J) and near Kuiyong in the northern part of Dapeng New District (Figure 2G), comprising plant remains of Equisetaleans such as *Neocalamites* and *Equisetites* as well as ferns of the genus *Cladophlebis* [24]. In other regions, the Qiaoyuan Formation shows a rich fossil record, e.g., northwest of Shenzhen in Foshan, where a diverse fossil flora of ferns (*Coniopteris*, *Todites*, and *Cladophlebis*), Bennettitaleans (*Otozamites*), ginkgophytes (*Baiera*), cycadophytes (*Thinnfeldia*) and the enigmatic *Nilssonia* was revealed [17], and northeast, in Huizhou, where plant remains (*Coniopteris* and *Nilssonia*) as well as marine fossils (bivalves: *Cardinia* and *Nuculana*) were found in layers of the Qiaoyuan Formation [18].

Lacustrine, partly volcaniclastic sediments, of the Lower to Middle Jurassic Tangxia Formation are distributed widely in the northern part of Longhua, the western part of Longgang, and the northern part of Luohu Districts (Figure 2). This unit proved to be fossiliferous in several localities: in the area around Bainikeng (Longgang) and Yantian (Dongguan) (Figure 2B), plant fossils of the conifers *Brachyphyllum* and *Pagiophyllum*, and the fern *Onychiopsis*, as well as freshwater branchiopods assigned to *Euestheria* and *Nestoria* were recovered from this unit [13,15,18,24]. A similar branchiopod assemblage (*Euestheria*, *Nestoria*, *Palaeolimnadia*, and *Paranestoria*) was reported from the Tangxia Formation further northeast in Xin Zhongkeng, Tangxia, and Qingxi (Dongguan), in addition to plant fossils (conifers: *Brachiophyllum, Elatides*, and *Pagiophyllum*) [15,17,18,24].

The Upper Jurassic Wutongshan Formation, distributed at Wutong Mountain in Luohu District, at Bijia Mountain in northern Dapeng New District, and the slopes of Qiniang Moutain in southern Dapeng New District (Figure 2), was formed in a phase of explosive, acidic volcanism; it is composed of pyroclastic sediments, mainly tuffs [24]. So far, no fossils have been described in these strata in Shenzhen; however, at the southern coast of the Tolo Channel in Hong Kong, fossils of the fish *Paralycoptera* sp. were found in lacustrine volcaniclastic mudstones of the Upper Jurassic Lai Chi Chong Formation [73], which is considered equal to the uppermost parts of the Wutongshan Formation [24].

4.3.3. Cretaceous

The Cretaceous successions in the Shenzhen area are characterized by terrestrial sediments, often containing plant fossils. In tuffaceous sandstones of the Lower Cretaceous Guancaohu Formation, which is exposed on Dapeng Peninsula (Figure 2), fossils of the conifer *Laricopsis* have been found in the Xiasha Village area, southwest of Wangmuwei in Dapeng New District (Figure 2I) [15,18,24].

In terms of Mesozoic terrestrial fauna, a few promising finds in the Cretaceous strata show the potential of research in this regard in the Shenzhen region. During an inspection of a collapsed slope after heavy rains in 2013 near Kengzi in Pingshan District (Figure 2F), technicians discovered what appeared to be fossil eggs in the collapsed debris. The subsequent investigation by researchers (Sun Yat-sen University) revealed several dinosaur nests and a large number of eggshells [23]. The nests were located within lacustrine sand- and siltstones of the Upper Cretaceous Dalangshan Formation. Initially identified as *Pinnatoolithus* [23] (considered a synonym of *Ovaloolithus* by [74]), the dinosaur eggs were subsequently assigned to the oofamily Stalicoolithidae [75]. The occurrence of dinosaur eggs in the Upper Cretaceous red beds that characterize the late Mesozoic extensional basins and half-grabens of South China is well documented, e.g., in the Nanxiong and Heyuan Basins [76–78]. However, this new find was the first evidence of dinosaurs in the Shenzhen area [23]. Moreover, these fossils provided stratigraphically important data, leading to a reassignment of the lower parts of strata previously considered to belong to the Palaeocene Xinzhuangcun Formation to the Late Cretaceous Dalangshan Formation. Hence, the signature of the respective parts in the geological map (Figure 2) displays the current ambiguousness, showing a need for future geological and palaeontological investigations to establish the K–Pg boundary in this area. Apart from these macrofossils, micropalaeontological analyses of the Dalangshan Formation in drilling cores in Shunde, Foshan, northwest of Shenzhen, revealed a rich record of freshwater ostracods (*Nanxiongium*, *Cypridea*, *Cyprois*, *Eucypris*, *Porpocypris*, and *Rhinocypris*), charophyte oogonia (*Charites*, *Gobichara*, *Hornichara*, *Rhabdochara*, and *Stephanochara*), and sporomorphs (*Classopollis*, *Exesipollenites*, *Plicapollis*, *Pterisisporites*, *Schizaeoisporites*, *Subtriporopollenites*, and *Tricolpopollenites*) [17].

4.4. Cenozoic Record

4.4.1. Palaeogene–Neogene

Successions of the Palaeocene Xinzhuangcun Formation are exposed in the areas of Kengzi and the Songzikeng Reservoir (northern Pingshan/eastern Longgang). Micropalaeontological analysis revealed a diverse fauna, including the ostracod *Eucypris* and the gastropods *Amnicala*, *Pupoides*, *Sanshuispira*, *Camenidae*, and *Hydrobia*, within rocks of this unit in Kengzi (Pingshan; Figure 2F) and Tongle (Longgang; Figure 2E) [24]. Further assemblages of ostracods (*Cyprois*, *Eucypris*, *Ilyocypris*, *Limnocythere*, and *Synocypris*), and gastropods (*Assiminea*, *Discostrobilops*, *Gracillinoconcha*(?), *Gyraulus*, *Pupoides*(?), *Strobilops*, and *Valvata*), as well as charophyte oogonia (*Charites*, *Gobichara*, *Grambastichara*, *Grovesichara*, *Gyrogona*, *Neochara*, *Obtusochara*, *Peckichara*, *Rhabdochara*, and *Stephanochara*), and ichnofossils were found in the Xinzhuangcun Formation in other localities in the region, i.e., in Jiangmen, Foshan, and Dongguan [17]. The fossil and sediment record indicates a fluvial-lacustrine depositional environment [17,24].

On Tung Ping Chau, a small island of Hong Kong in the Mirs (=Dapeng) Bay less than four kilometers off the coast of Dapeng Peninsula (Figure 2H), strata from the Palaeocene Ping Chau Formation contained insect fossils from the orders Coleoptera (*Explansimarginis*, *Lithocantharis*, *Otiorhynchites*, *Paklapwania*, *Wongyekokia*, and Gyrinidae), Blattodea (*Diploptera*), and Hemiptera (*Allocercopis*) [18]. Furthermore, ostracods (*Eucypris*(?) and *Otiorhynchites*) and plant remains (angiosperms: *Amehoneuron*, *Dicotylophyllum*; conifers: *Brachyphyllum*; Bennettitales: *Otozamites*) were found [18]. Palynological analysis revealed a diverse sporomorph assemblage containing *Engelhardtioidites*, *Pinuspollenites*, *Jarzenipollenites*, *Pterisisporites*, and *Ulmipollenites* [18].

4.4.2. Quaternary

The Quaternary sequences in Shenzhen are composed of marine, lagoonal, alluvial, and eluvial layers. While research on Quaternary macrofossils in the Shenzhen area is almost inexistent, the microfossil record has received greater attention, which provides valuable information about the evolution of the local environment during the Pleistocene and Holocene, as well as for stratigraphical correlations. Furthermore, fossil observations in equivalent strata in adjacent areas provide information about the potential fossil records within these successions in Shenzhen.

The Pleistocene in this region is divided into three units, i.e., in stratigraphically ascending order, the Shipai Formation, Xinanzhen Formation, and Sanjiao Formation; the Holocene comprises four units, i.e., the Xingtan Formation, Henglan Formation, Wanqingsha Formation, and Denlongsha Formation (e.g., [63]). The Shipai Formation is known to contain gastropods (*Acteocina*, *Alvania*, *Marstonia*, and *Pseudoliotia*), bivalves (*Potamoeorbula* and *Arca*), cirripeds (*Balanus*), scaphopods (*Dentalium*), sporomorphs, and freshwater diatoms [17]. A drilling core in Foshan revealed a diatom fauna comprising *Coscinodiscus*, *Cyclotella*, *Cymbella*, and *Melosira*, as well as sporomorphs within the Shinanzhen Formation [17]. Foraminifera (*Elphidium*) have also been observed in this formation [63]. Several boreholes in Minzhu Village, Shajing Town in northern Bao'an, and Xinmin Village, Chang'an Town, Dongguan, contained marine microfossils within the Upper Pleistocene Sanjiao Formation and the Holocene Henglan and Wanquingsha Formations [16]. The recovered assemblages contained foraminifera of the genera *Ammonia*, *Elphidium*, *Cavarotalia*, *Cibicides,* and *Quinqueloculina* (see also [63]). Furthermore, diatoms of the genera *Cyclotella*, *Cymbella*, *Diploneis*, *Nitzschia*, *Pinnularia*, and *Tryblionella*, the ostracod *Sinocytheridea,* the foraminifer *Elphidium*, as well as testate amoebae were recorded in Holocene sediments along the Shenzhen River (e.g., Yumincun, southern Luohu) and in lagoons in the Dapeng area [15,63,79]. A study by the Guangzhou Institute of Geography on the landforms of Shenzhen recovered bivalves, including oysters, windowpane oysters (*Placuna placenta*), and river clams, from the upper Holocene along the Shenzhen River [79]. Apart from these, wood, leaf, and other plant fragments have been found throughout the Quaternary successions [16,17].

The Quaternary sediments in Shenzhen show a rich record of terrestrial palynomorphs, which has been used as an important tool to reconstruct the evolution of the local vegetations. Zhang & Yu [80] distinguished 10 palynological assemblages in a succession recovered from a borehole in Shenzhen and described changes in the palaeoenvironment and climate during the Quaternary. Similarly, Jin et al. [81] divided the Pleistocene and Holocene records of sporomorphs from boreholes in the Pearl River Mouth Basin and the northern coast of Shenzhen Bay into in total 18 palynological zones and described the respective changes in vegetation, local climate, and sea level in the Shenzhen region.

Table 1. Animal macrofossil taxa recorded in Shenzhen, with known occurrence localities and strata. Localities A–K are as in Figure 2; locality L: various locations in the Quaternary sediments; stratigraphic units are as in Figure 3.

Group	Taxon	Locality										Unit	Reference
		A	B	C/D	E/F	G	H	I	J	K	L		
ammonites	*Hongkongites hongkongensis* Grabau 1923								■			J_1j	[22]
	Hongkongites sp.								■			J_1j	[15,18,21,24]
bivalves	"Sea Moon" (*Placuna placenta* Linnaeus 1758)										■	Qh	[15]
	oysters										■	Qh	[15]

	river clams										■	Qh	[15]
	undefined shell fragments										■	Qh	[16]
	Astarte sp. cf. *A. voltzii* Goldfuss 1837								■			J_1j	[15,18,24]
	Astarte consobrina Chapuis & Dewalque 1853								■			J_1j	[15,18,21,24]
	Astarte sp.								■			J_1j	[15,18,22,24]
	Cardinia sp.								■			J_1j	[15,18,24]
	Entolium sp.								■			J_1j	[15,18,24]
	Homomya sp.								■			J_1j	[15,18,21,22,24]
	Parainoceramya sp.								■			J_1j	[15]
	Lima (*Plagiostoma*) sp.									■		J_1j	[15]
	Luciniola hasei Hayami 1959								■			J_1j	[15,18,21,24]
	Luciniola hasei var. *subtrigona* Chen et Huang								■			J_1j	[15,18,21,24]
	Luciniola sp.								■			J_1j	[21,22]
	Mesomiltha sp.								■			J_1j	[22]
	Mesomiltha(?) *regularis* Huang 1986								■			J_1j	[15,18,21,24]
	Mesomiltha(?) *shenzhenensis* Huang 1986								■			J_1j	[15,18,21,24]
	Mytilus sp.									■		J_1j	[15,24]
	Nuculana sp.									■		J_1j	[15,24]
	Palaeoneilo jinjiensis Chen 1982									■		J_1j	[15,24]
	Parainoceramus sp.								■			J_1j	[24]
	Plagiostoma sp.									■		J_1j	[24]
	Protocardia sp.								■			J_1j	[21,22]
	Protocardia sp. cf. *P. kurumensis* Hayami 1958								■			J_1j	[15,21,24]
	Protocardia suborbicularis Fan 1963								■			J_1j	[15,18,21,24]
	Protocardia transversa Fan 1963								■			J_1j	[15,18,24]
	Pseudotrapezium praelonga (Terquem and Piette 1868) Huang 1986								■			J_1j	[15,18,21]
	Pseudotrapezium sp.								■			J_1j	[22]
	Pseudotrapezium sp. cf. *P. praelonga* (Terquem & Piette, 1865) Huang 1986								■			J_1j	[15,18,21,24]
	Pseudotrapezium triangularis (Terquem 1855) Huang 1986								■			J_1j	[15,18,21,24]
	Radulonectites sp.									■		J_1j	[15,24]
	Radulonectites(?) *exsertus* Chen 1982									■		J_1j	[15,24]
	Ryderia guangdongensis (Zhang in Zhang et al. 1977) Yin and McRoberts 2006					■				■		J_1j	[15,24]
	Thracia(?) sp.								■			J_1j	[15,18,24]
brachiopods	*Chonetes* sp.			■								C_1c	[15,24]
	Choristites weiningensis (Grabau 1923) Chao 1929			■								C_1c	[13,15,18,24]
	Echinoconchus elegans Norwood and Pratten 1855			■								C_1c	[13,15,18,24]
	Kansuella maxima (McCoy, 1844) Ding and Qi 1983			■								C_1c	[13,15,18,24]
	Schuchertella sp.			■								C_1c	[13,15,18,24]

branchiopods	*Euestheria* sp. aff. *E. shandanensis* Chen in Zhang et al. 1976		■									$J_{1-2}t$	[15,24]
	Nestoria sp.		■									$J_{1-2}t$	[15,24]
bryozoans	undefined			■								C_1c	[15]
	Fenestella sp.			■								C_1c	[13,15,18,24]
corals	*Desmophyllum* sp.	■										T_3x	[16,17]
	Kueichouphyllum sp.			■								C_1s	[15]
	Lithostrotion portlocki (Bronn 1948) Milne-Edwards and Haime 1851			■								C_1s	[15]
	Syringopora aff. *dingmanae* Nelson 1962			■								C_1s	[15]
crinoids	undefined			■								C_2h	[15]
				■								C_1s	[24]
	Cyclocyclicus sp.			■								C_1c	[13,15,18]
gastropods	*Amnicala* sp.				■							P_1x	[24]
	Camenidae				■							P_1x	[24]
	Hydrobia sp.				■							P_1x	[24]
	Pupoides (*Ischnopupoides*) sp. aff. *P.* (*I*) *antiguus* Yü and Wang 1977				■							P_1x	[24]
	Sanshuispira hexalamella Yü and Zhang 1982				■							P_1x	[24]
	Sanshuispira sp. cf. *S. hexalamella* Yü and Zhang 1982				■							P_1x	[24]
insects	*Allocercopis punctatis* Lin in Lin and Lee 1997						■					P_1pc	[18]
	Allocercopis sp.						■					P_1pc	[18]
	Diploptera sp.						■					P_1pc	[18]
	Explansimarginis evidis Lin in Lin and Lee 1997						■					P_1pc	[18]
	Gyrinidae						■					P_1pc	[18]
	Lithocantharis lunglokshuiensis Lin in Lin and Lee 1997						■					P_1pc	[18]
	Otiorhynchites williamsi Cockerell 1943						■					P_1pc	[18]
	Paklapwania sp.						■					P_1pc	[18]
	Wongyekokia(?) *angustris* Lin in Lin and Lee 1997						■					P_1pc	[18]
trilobites	*Phillipsia* sp.			■								C_1c	[13,15,18,24]
vertebrates	dinosaur eggs				■							K_2d	[23]

Table 2. Plant macrofossil taxa recorded in Shenzhen, with occurrence localities and strata. Localities A–K are as in Figure 2; locality L: various locations in the Quaternary sediments; stratigraphic units are as in Figure 3.

Group	Taxon	Locality										Unit	Reference
		A	B	C/D	E/F	G	H	I	J	K	L		
angiosperms	*Amesoneuron* sp.						■					P_1pc	[18]
	Dicotylophyllum sp.						■					P_1pc	[18]
Bennettitales	*Otozamites* sp.						■					P_1pc	[18]
									■			J_1j	[22]
	Otozamites sp. cf. *O. hsiangchiensis* Sze 1949								■			J_1j	[22]

	Pterophyllum (*Ctenophyllum*) sp.	■								T_3x	[16,17,24]
	Ptilophyllum sp.							■		J_1j	[22]
	Williamsonia shenzheniana nom. nud.							■		J_1j	[67,68]
	Williamsoniella sp.							■		J_1j	[22]
	Zamites sp.							■		J_1j	[22]
conifers	*Brachyphyllum* sp.					■				P_1pc	[18]
			■							$J_{1-2}t$	[13,15,18,24]
	Elatides sp.		■							$J_{1-2}t$	[13,15,24]
	Elatocladus sp.							■		J_1j	[22]
	Laricopsis angustifolia Fontaine 1889						■			K_1gc	[15,18,24]
	Pagiophyllum sp.		■							$J_{1-2}t$	[15,18,24]
								■		J_1j	[22]
	Podozamites sp.							■		J_1j	[18]
	Sphenolepis sp.							■		J_1j	[22]
cycads(?)	*Nilssonia* sp.							■		J_1j	[22]
Equisetales	*Archaeocalamites scrobiculatus* (Brongniart 1820) Stur 1875								■	C_1d	[14,15,24]
	Equisetites sp.				■					J_1q	[24]
								■		J_1j	[15,22]
	Neocalamites sp.				■					J_1q	[24]
	Neocalamites sp.							■		J_1j	[15,22]
		■								T_3x	[16,24]
ferns	*Cladophlebis* sp.							■		J_1q	[24]
								■		J_1j	[22]
	Clathropteris meniscioides (Brongniart 1925) Brogniart 1828	■								T_3x	[16,17]
	Clathropteris sp.							■		J_1j	[22]
	Clathropteris sp. cf. *C. meniscoides* Brongniart 1828							■		J_1j	[22]
	Dictyophyllum sp.							■		J_1j	[22]
	Onychiopsis elongata (Geyler 1877) Yokoyama 1889		■							$J_{1-2}t$	[13]
	Phlebopteris sp. cf. *P. braunii* (Goeppert 1841) Harris 1980	■								T_3x	[16]
	Rhodeopteridium giganteum (Stur 1875) Moseychik 2014								■	C_1d	[24]
	Rhodeopteridium giganteum(?) (Stur 1875) Moseychik 2014			■						C_1c	[15]
	Rhodeopteridium hsianghsiangense (Sze 1951) Zhang, Zhao et Wu 1980			■						C_1c	[15]
	Rhodeopteridium sp.								■	C_1d	[14,15,24]
	Rhodeopteridium sp. cf. *R. hsianghsiangense* (Sze 1951) Zhang, Zhao et Wu 1980								■	C_1d	[14,15,24]
lycophytes	*Stigmaria* sp.								■	C_1d	[14,15]
	Sublepidodendron mirabile (Nathorst 1920) Hirmer 1927								■	C_1d	[14,15,24]
	Sublepidodendron sp.								■	C_1d	[14,15,24]
seed ferns	*Alethopteris* sp.			■						C_1c	[15]
	Neuropteris sp.			■						C_1c	[15]

		A	B	C/D	E/F	G	H	I	J	K	L	Unit	Reference
	Paripteris gigantea (Sternberg 1825) Gothan 1941			■								C_1c	[13,15,18]
	Paripteris sp. cf. *P. gigantea* (Sternberg 1825) Gothan 1941			■								C_1c	[15]
	Taeniopteris sp.								■			J_1j	[22]
		■										T_3x	[16,24]
	undefined plant fragments										■	Qh	[16,81]

Table 3. Microfossil taxa recorded in Shenzhen, with occurrence localities and strata. Localities A–K are as in Figure 2; locality L: various locations in the Quaternary sediments; stratigraphic units are as in Figure 3.

Group	Taxon	Locality										Unit	Reference
		A	B	C/D	E/F	G	H	I	J	K	L		
diatoms	*Cyclotella striata* (Kützing 1844) Grunow 1880										■	Qh	[15,79]
	Cymbella gracilis (Ehrenberg 1841) Kützing 1844										■	Qh	[15,79]
	Oricymba japonica (Reichelt 1898) Jüttner, Cox, Krammer and Tuji, 2010										■	Qh	[79]
	Diploneis elliptica (Kützing 1844) Cleve 1894										■	Qh	[79]
	Diploneis fusca (Gregory 1857) Cleve 1894										■	Qh	[79]
	Diploneis smithii (Brébisson 1856) Cleve 1894										■	Qh	[79]
	Giffenia cocconeiformis (Grunow 1880) Round and Basson 1997										■	Qh	[79]
	Homoeocladia granulosa (Leuduger-Fortmorel 1879) Kuntze 1898										■	Qh	[79]
	Pinnularia borealis Ehrenberg 1843										■	Qh	[15,79]
	Tryblionella navicularis (Brébisson 1849) Ralfs in Pritschard 1861										■	Qh	[15]
foraminifera	*Ammonia beccarii* (Linnaeus 1758)										■	Qh	[16,63]
	Ammonia tepida (Cushman 1926)										■	Qh	[63]
	Cavarotalia annectens (Parker and Jones 1865)										■	Qh	[16,63]
	Cibicides refulgens Montfort 1808										■	Qh	[63]
	Elphidium hispidulum Cushman 1936										■	Qh	[63]
											■	Qp	[16]
	Elphidium limpidum He, Hu and Wang 1965										■	Qh	[16,63]
	Elphidium nakanokawaense Shirai 1960										■	Qh	[15]
	Endothyra ex. gr. *Globulus* (Eichwald 1859)			■								C_1s	[15,24]
	Eostaffella sp.			■								C_1s	[15]
	Eotuberitina sp.			■								C_1s	[15,24]
	Palaeotextularia sp.			■								C_1s	[15,24]
	Quasifusulina sp.			■								C_2h	[15]

	Quinqueloculina seminulum (Linnaeus 1758)	Qh	[16,63]
ostracods	*Eucypris sanshuiensis* Zhang 1985	P_1x	[24]
	Eucypris(?) sp.	P_1pc	[18]
	Otiorhynchites aberranis Lin 1997	P_1pc	[18]
	Sinocytheridea latiovata Hou and Chen in Hou et al. 1982	Qh	[15]
testate amoeba	*Centropyxis* sp.	Qh	[15]
	undefined	Qh	[15]
sporomorphs	*Abietineaepollenites* sp.	P_1pc	[18]
	Acrostichum sp.	Qp	[80,81]
	Adianium sp.	Qh	[80]
	Aegiceras sp.	Qh	[80]
	Alsophila sp.	Qh	[80]
	Alsophila sp.	Qp	[80]
	Altingia sp.	Qh	[80]
	Arecaceae	Qh	[80]
	Brassicaceae	Qh	[80]
	Castanopsis sp.	Qh	[80,81]
		Qp	[80,81]
	Cibotium sp.	Qp	[81]
	Concentricystes sp.	Qp	[80]
	Coniogramme sp.	Qh	[80,81]
	Cyathea	Qh	[80,81]
	Cyathea sp.	Qp	[80,81]
	Cyperaceae	Qh	[80,81]
	Diplopterygium sp.	Qh	[80]
	Elaeocarpus sp.	Qh	[80,81]
		Qp	[80]
	Engelhardtioidites sp.	P_1pc	[18]
	Euphorbia sp.	Qh	[80]
	Eurya sp.	Qh	[80]
	Fagus sp.	Qp	[81]
	Gramineae	Qh	[80,81]
	Homalium sp.	Qh	[80]
	Jarzenipollenites sp.	P_1pc	[18]
	Juglans sp.	Qp	[81]
	Liquidambar sp.	Qh	[80]
		Qp	[81]
	Lygodium sp.	Qp	[80]
	mangrove pollen	Qh	[80,81]
	Microlepia sp.	Qp	[80]
	Osmanthus	Qh	[80]
	Pinus sp.	Qh	[80,81]
		Qp	[81]
	Pinuspollenites sp.	P_1pc	[18]
	Poaceae	Qh	[80]
	Polypodiaceae	Qh	[80,81]
		Qp	[80,81]

Pteridium sp.	Qh	[80]
	Qp	[80]
Pteris sp.	Qh	[80,81]
	Qp	[80,81]
Pterisisporites sp.	P_1*pc*	[18]
Quercus sp.	Qh	[80,81]
	Qp	[80,81]
Ranulaceae	Qh	[80]
Sonneratia sp.	Qh	[80]
Ulmipollenites sp.	P_1*pc*	[18]
Ulmipollenites minor Groot and Groot 1962	P_1*pc*	[18]

5. Geoheritage Development in Shenzhen

While in China, awareness of geoconversation has existed since the 1950s and important geosites were already included in the National Nature Reserve System in 1956, efforts toward geoheritage development and conversation have drastically increased since the 1980s [82]. China has successively formulated and issued a series of policies, regulations and specifications for the promotion of geological heritage protection, with some promising results [82,83]. A national survey of important palaeontological localities and geoheritage sites was completed in 2010, reporting 182 national and 34 provincial geoparks, registering important geological and palaeontological relics and formulating technical requirements for future geological heritage efforts [84]. In 2018, the results of the China Geological Survey were published, providing data to contribute to the management, including conservation efforts, of national and provincial geoheritage sites; for Guangdong Province, a list of 162 important geoheritage sites was established.

In Shenzhen, more than 80 types of geological heritage sites, including exposed stratigraphic profiles, volcanic outcrops, fossil localities, important rock and mineral producing areas (mining sites), and various landforms, have been identified. Within the "Shenzhen Geological Relics Protection Plan (2010–2020 Renovation and Improvement Period)," ten geoheritage distribution areas were defined based on geoheritage type, distribution density, and combined characteristics: Bao'an Yangtaishan Geological Relic Landscape Area, Bao'an Fenghuangshan Geological Relic Landscape Area, Bao'an Apoji Geological Relic Landscape Area, Nanshan Nei Lingding Island Geological Relic Landscape Area, Luohu Wutongshan Geological Relic Landscape Area, Yantian Meishajian-Egongji Geological Relic Landscape Area, Pingshan Maluanshan Geological Relic Landscape Area, Pingshan Bijiashan-Pai Yashan Geological Relic Landscape Area, Dapeng Peninsula National Geopark Landscape Area, and Dapeng Peninsula Coastal Geological Relic Landscape Area [20]. Additionally, about 60 major geological heritage sites were graded and improved, and measures and suggestions for improvement were proposed for each site [20].

In order to promote and protect the geological heritage of the region, the Shenzhen Museum of Paleontology as well as the Dapeng Peninsula National Geopark and Museum were established. The former was built in 2001 next to the Fossil Forest at the Fairy Lake Botanical Gardens in the Liantang Subdistrict, Luohu. While the Fossil Forest, erected in 1997, is not composed of local fossil specimens but comprises more than 400 Jurassic petrified trees brought from other places in China, such as Xinjiang and Inner Mongolia, it contributes to the promotion of interest in geological and particularly palaeontological history. The Shenzhen Museum of Paleontology's main purpose is to build fossil collections for the display to the public as well as for research. In 2002, it became the sixth National Popular Science Education Base of the Chinese Paleontological Society. In 2005, after a detailed and comprehensive investigation and research of various geological relics in Dapeng Peninsula, the Shenzhen Municipal Government applied for National Geopark status, which opened in 2010 as the Dapeng Peninsula National Geopark. The geopark's museum opened in 2013 as a new important tourist attraction on Shenzhen's Dapeng Peninsula. It is located near the Qiniang Mountain Dome tourist area in Xindacun and presents the unique local geological and palaeontological history. This museum, the Shenzhen Palaeontological Museum, and Shenzhen Museum actively promote the popularization of geoscience education by providing numerous activities and exhibitions and publishing popular science books, including a geological-themed comic book.

Shenzhen also has a long history of mining. In 2005, the first Mine parks were approved by the former Ministry of Land and Resources. The Shenzhen Pinghu Fenghuangshan National Mine Park, which is an area of open-pit mining of diabase, opened in 2012, while the construction of the Guangdong Shenzhen Pengqian National Mine Park, where marble was mined underground, has remained stagnant after its initial planning and design in 2008 [20].

6. Discussion

The review of geological and palaeontological surveys and scientific studies concerning the Shenzhen area reveals a diverse fossil record in rocks of various periods throughout the Phanerozoic, as well as a general lack of research conducted on them in the region. Several localities with notable fossil-bearing strata have been identified, which can offer a promising base for future research and geoheritage development.

Two of the most important fossil localities in Shenzhen are the Shayingguanling site in Shuitousha, Dapeng New District (Figure 2J), with its exceptionally preserved Early Jurassic land plant flora, and the dinosaur egg site of Kengzi, Pingshan District (Figure 2F). Their significance as geoheritage sites has been recognized by the city of Shenzhen and these localities were placed under geoheritage protection, which includes regular inspections and monitoring, as well as prohibition of access to the sites [20]. However, several other localities also offer great potential for both geoheritage development and research. Middle–Upper Devonian sediment rocks, which are exposed in different places in the eastern part of Shenzhen, are a promising target for palaeontological studies, as equivalent strata in Hong Kong and other places revealed marine and terrestrial fossils, including fish, plants, and microfossils. Carboniferous successions are widespread in Shenzhen and proved to be fossiliferous, but, thus far, have not been the focus of palaeontological research. An investigation of the land plant remains found on the northern coastal slopes of Paiya Mountain (Figure 2K) may provide valuable insights into the terrestrial ecosystems of the region during the Early Carboniferous, while the outcops near He'ao, Longgang (Figure 2C), are a promising locality for the study of shallow marine benthic faunas from this epoch. The slopes of Paiya Mountain also include Devonian sediment rocks, allowing palaeontological sampling along stratigraphic successions from the Middle Devonian to Lower Carboniferous. Lower Triassic sediment rocks are rather scarce in Shenzhen, but their marine and terrestrial fossils are certainly of palaeontological interest, particularly those exposed in Hongquaotou in Bao'an District (Figure 2A). Apart from the localities presented herein, palaeontological surveys may target those strata known to be fossil-rich in adjacent areas, particularly the Middle–Upper Devonian successions that crop out in the eastern parts of Shenzhen and the widespread Lower–Middle Jurassic rocks. With dinosaur eggs found in Kengzi in strata previously assigned to the Palaeocene, the identification of the K–Pg boundary may represent a major subject for palaeontological research. Moreover, micropalaeontological and palynological studies on Precambrian and Phanerozoic successions can offer great opportunities for research and provide a great tool for more precise dating of Shenzhen's various sediment rocks by biostratigraphic correlations.

In China, sites of geological heritage are part of natural resources and thus state-owned assets [85]. Geoheritage development requires city- and district-level managing to comprehensively take into account all relevant factors to fully realize the value of geological heritage, including resources, property, geological history, aesthetic qualities, and tourism. The city of Shenzhen began to conduct geological heritage exploration early and invested greatly in its efforts for geoheritage development [20]. This review on the palaeontology of Shenzhen provides a base for more targeted survey efforts to identify outcrops of particular geoheritage significance. As Gong and Zhang [20] already concluded, further development is needed, particularly with regard to the discovery of new fossil-rich sites, the expansion and optimization of geoheritage protection, and the strengthening of cooperation with universities and other research institutions. The protection of fossil-producing sites in particular needs to be in focus in the city's further geoheritage development. More targeted inspections of the herein mentioned localities and sediment rocks by specialists of research institutions in cooperation with city officials may lead to the identification of stratigraphic profiles and other outcrops that qualify for a possible designation of new geoheritage sites. Such sites need to be targeted for conservation efforts, including the regulation of access, as uncontrolled collection of fossils is a threat to in situ palaeontological heritage. Furthermore, the valorization of existing geoheritage sites will contribute to raising awareness on their palaeontological significance [86]. Both the Shuitousha and Kengzi sites are so far underdeveloped as areas of public interest; valorization efforts in combination with conversation would promote local tourism while informing the public of the area's past environment. Geoheritage development of important fossil sites may increase risk in terms of conservation as it brings attention to previously lesser known outcrops (see [87,88]); however, it can also promote public awareness of, as well as a respectful approach to, the in situ palaeontological heritage. For some areas in Shenzhen with several outcrops, geotouristic routes with a palaeontological focus may be envisioned, e.g., in the central part of Dapeng New District (localities I and J, Figure 2), with geoheritage sites occurring along new and/or pre-existing hiking paths, which can inform people about the relevance of the local geological history and fossil record. While Shenzhen is a rapidly developing city, which may hinder geoheritage development in certain areas, the Hong Kong UNESCO Global Geopark shows that conservation of geoheritage can be combined with sustainable development even in highly populated areas [89].

Apart from the in situ geoheritage (e.g., geosites [90]), ex situ geoheritage, such as museum collections, plays an important role [2]. Palaeontological collections that are promising as geoheritage are stored at the Shenzhen Palaeontological Museum of Xianhu Botanical Gardens, the Shenzhen Museum, and the Dapeng Peninsula National Geopark Museum. After the implementation of the "Palaeontological Fossil Protection Regulations" (State Order No. 580) in 2011, the Shenzhen Palaeontological Museum and the Shenzhen Museum collected about 1500 fossil specimens [20]. Further expansion and a more effective curation of fossil collections in museums, also in view of display and exhibitions, will not only provide grounds for palaeontological research but also enhance earth science popularization. Finally, both geoheritage development and research profit greatly from a mutual enhancement between palaeontologically relevant geosites and local museums. Public outreach efforts, such as popular science exhibitions and outdoor activities, promote science education and awareness while also contributing to culture, tourism, and recreation.

7. Conclusions and Perspectives

The fossil record of Shenzhen reveals the dynamic history of this part of Cathaysia during the Phanerozoic. The area offers promising opportunities for the research of middle to late Palaeozoic marine and terrestrial ecosystems. Although the Devonian fossil record in Shenzhen is so far poor, the rich macro- and microfossil records in equivalent strata in adjacent areas (e.g., Jiangmen, Huizhou, and Hong Kong) indicate that successions of this age in the Shenzhen area, particularly the Shuangtou Formation, have great potential for future research. The Carboniferous successions (the Dahu, Shidengzi, and Ceshui Formations and Hutian Group) in Shenzhen are rich in both marine and terrestrial fossils, particularly in the Paiya Mountain area (Figure 2K) on Dapeng Peninsula and in

Longgang (e.g., the He'ao area; Figure 2C); however, not much research has been performed on these units so far.

Shenzhen has undoubtedly great potential for the investigation of Mesozoic terrestrial and marine ecosystems. Wang et al. [22] already noted that the Shenzhen area is one of the most promising regions in southern China for the research of Mesozoic coal-bearing strata as well as Triassic–Jurassic boundary events. Several localities in Shenzhen provide a rich fossil record of early Mesozoic (Late Triassic–Early Jurassic) marine ecosystems and terrestrial floras. Of particular palaeontological interest are the Upper Triassic Xiaoping Formation, e.g., in Hongqiaotou Village in northern Bao'an (Figure 2A), and the Lower Jurassic Jinji Formation, with several fossiliferous outcrops on Dapeng Peninsula, including Nan'ao-Shuitousha (Figure 2J), Hengshan Mountain (near Figure 2K), and Kuiyong (Figure 2G). Furthermore, the northern parts of Pingshan District have great potential for research of the K–Pg boundary in terrestrial (lacustrine) strata (e.g., Figure 2F). The discovery of dinosaur eggs in this area and potential future palaeontological investigations provide a base to further develop science popularization and education in this region and has great value for geological tourism. Some of these eggs are stored and presented at the Geopark Museum on Dapeng Peninsula, where they are considered a highlight of the collections.

The Cenozoic microfossil and palynological records are valuable tools for climate and environmental analyses; they allow us to reconstruct the changes in the palaeoenvironment of this region, which ultimately leads to the ecosystems that are prevalent in and around Shenzhen today. In the context of the fast-developing city and of climate change, further micropalaeontological research, particularly on drilling cores, may provide valuable data for assessing past, recent, and future changes in the terrestrial and shallow marine ecosystems of Shenzhen.

While the city of Shenzhen has greatly contributed to local geoheritage development, further efforts, including more targeted palaeontological surveys as well as conservation and valorization of palaeontologically relevant geological features, will be profitable for research, science popularization, tourism, and recreation.

Author Contributions: Conceptualization, D.M.K. and T.B.; investigation, D.M.K.; project administration, D.M.K. and T.B.; resources, D.M.K., Y.G., H.C., and T.B.; visualization, D.M.K.; writing—original draft, D.M.K.; writing—review & editing, D.M.K., Y.G., H.C., L.L., and T.B.; validation, Y.G., H.C., L.L., and T.B.; funding acquisition, D.M.K., H.C., and T.B. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the National Natural Science Foundation of China (42302002, W2433096, 42302003); the Open for Collaboration Grant from Yunnan Key Laboratory for Palaeobiology, Yunnan University (2023YKLPKF02); the Shenzhen Science and Technology Program (grant nos. 202206193000001, 20220815111354002); and the Human Resources and Social Security Bureau of Shenzhen Municipality (szbo202406).

Data Availability Statement:

No new data were created or analyzed in this study. Data sharing is not applicable to this article.

Acknowledgments: The authors want to thank the funding agencies and organizations that contributed to this study. Special appreciation for Du Xuheng for his help with Chinese literature translations.

Conflicts of Interest: The authors declare no conflicts of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Bétard, F.; Hobléa, F.; Portal, C. Les géopatrimoines, de nouvelles ressources territoriales au service du développement local. *Ann. Geogr.* **2017**, *717*, 523–543.
2. Reynard, E.; Brilha, J. Geoheritage: A multidisciplinary and applied research topic. In *Geoheritage—Assessment, Protection, and Management*, 1st ed.; Reynard, E., Brilha, J., Eds.; Elsevier: Amsterdam, The Netherlands; Oxford, UK; Cambridge, MA, USA, 2018; pp. 3–9, ISBN 978-0-12-809531-7.
3. Larwood, J.G.; Badman, T.; McKeever, P.J. The progress and future geoconversation at a global level. *Proc. Geol. Assoc.* **2013**, *124*, 720–730.
4. Crofts, R.; Gordon, J.E.; Santucci, V.L. Geoconversation in protected areas. In *Protected Area Governance and Management*; Worboys, G.L., Lockwood, M., Kothari, A., Feary, S., Pulsford, I., Eds.; ANU Press: Canberra, Australia, 2015; pp. 531–568.
5. Brilha, J. Geoheritage: Inventories and evaluation. In *Geoheritage—Assessment, Protection, and Management*, 1st ed.; Reynard, E., Brilha, J., Eds.; Elsevier: Amsterdam, The Netherlands; Oxford, UK; Cambridge, MA, USA, 2018; pp. 69–86, ISBN 978-0-12-809531-7.
6. Pralong, J.P.; Reynard, E. A proposal for a classification of geomorphological sites depending on their tourist value. Il Quaternatio. *Alp. Mediterr. Quat.* **2005**, *18*, 315–321.
7. Coratza, P.; Hobléa, F. The specifities of geomorphological heritage. In *Geoheritage—Assessment, Protection, and Management*, 1st ed.; Reynard, E., Brilha, J., Eds.; Elsevier: Amsterdam, The Netherlands; Oxford, UK; Cambridge, MA, USA, 2018; pp. 87–106, ISBN 978-0-12-809531-7.
8. Gray, M. Geodiversity and geoconservation: What, why, and how? In *Papers Presented at the George Wright Forum*; Santucci, V.L. Ed.; Book Concern Printers: Hancock, MI, USA, 2005; pp. 4–12.
9. Schumann, A.; Muwanga, A.; Lehto, T.; Staudt, M.; Schlüter, T.; Kato, V.; Namboyera, A. Ugandan geosites. *Geol. Today* **2015**, *31*, 59–67.
10. Newsome, D.; Dowling, R. Geoheritage and geotourism. In *Geoheritage—Assessment, Protection, and Management*, 1st ed.; Reynard, E., Brilha, J., Eds.; Elsevier: Amsterdam, The Netherlands; Oxford, UK; Cambridge, MA, USA, 2018; pp. 305–321, ISBN 978-0-12-809531-7.
11. Reynard, E.; Giusti, C. The landscape and the cultural value of geoheritage. In *Geoheritage—Assessment, Protection, and Management*, 1st ed.; Reynard, E., Brilha, J., Eds.; Elsevier: Amsterdam, The Netherlands; Oxford, UK; Cambridge, MA, USA, 2018; pp. 147–166, ISBN 978-0-12-809531-7.
12. Zhu, T. *Guangdong and Guangxi Geological Interim Report 26: Geology of the Two Counties of Dongguan and Bao'an, Guangdong*; Liangguang Geological Survey Institute: Guangzhou, China, 1932. (In Chinese)
13. Team No. 761 of the Guangdong Provincial Bureau of Geology. *People's Republic of China Regional Geological Survey Report—1 : 200 000 (Sheets F-50-VII Huiyang, F-50-VIII Bao'an)*; Guangdong Provincial Bureau of Geology: Guangzhou, China, 1965; Volume 1. (In Chinese)
14. Shenzhen Geological Bureau. Geological tables and maps of the Shenzhen districts. *Newsl. Geol. Soc. Hong Kong* **1984**, *2*, 10–17.
15. Liu, Y.; Zhang, Y. *People's Republic of China Regional Geological Survey Report—1 : 50 000 (Sheets F-49-60-B Bao'an, F49-60-D Shekou, F-50-49-A Shenzhen, F-50-49-B Wangmuwei). Regional Survey Summary Report of the People's Republic of China*; Guangdong Provincial Bureau of Geology: Guangzhou, China, 1985. (In Chinese)
16. Regional Survey Team of the 75th Geological Brigade of the Guangdong Provincial Bureau of Geology and Mineral Resources. *People's Republic of China Regional Survey Summary Report—1 : 50 000 (sheets F49E007024 Dalang and F49E008024 Shajing)*; Guangdong Provincial Bureau of Geology and Mineral Resources: Guangzhou, China, 1998. (In Chinese)
17. Zhuang, W.; Liu, J.; Li, W.; Xu, Y.; Chen, S.; Huang, Y.; Zhang, Z. *People's Republic of China Regional Geological Survey Report—1 : 250 000 (Sheet F49C002004 Jiangmen City Area)*; Guangdong Provincial Geological Survey Institute: Guangzhou, China, 2003. (In Chinese)
18. Zhuang, W.; Liu, J.; Li, W.; Xu, Y.; Chen, S.; Huang, Y.; Zhang, Z. *People's Republic of China Regional Geological Survey Report—1 : 250 000 (Sheet F50C002001 Hong Kong)*; Guangdong Provincial Geological Survey Institute: Guangzhou, China, 2003. (In Chinese)
19. Compiling Group of Shenzhen Geology. *Shenzhen Geology*, 1st ed.; Qi, X., Gong, Y., Eds.; Geological Publishing House: Beijing, China, 2009; ISBN 978-7-116-06012-8. (In Chinese)
20. Gong, P; Zhang, H.Y. Discussion on the current situation and management suggestions of geological heritage protection in Shenzhen city. *China Min. Mag.* **2018**, *27*, 28–31. (In Chinese with English abstract)
21. Huang, Z.Z. Discovery of Early Jurassic Bivalves from Shenzhen area. *Acta Palaeontol. Sin.* **1986**, *25*, 577–584. https://doi.org/10.19800/j.cnki.aps.1986.05.010 (In Chinese with English abstract)
22. Wang, Y.; Wu, X.; Yang, X.; Duan, W.; Li, L. The discovery of Jurassic plants in Shenzhen of Guangdong, southern China and related significance. *Chin. Sci. Bull.* **2014**, *59*, 3630–3637. https://doi.org/10.1007/s11434-014-0449-5.
23. Liu, C.; Yin, J.; Zhu, Z.; Wu, Y.; Che, P. Dinosaur eggs found in Pingshan, Shenzhen and their geological significance. *Acta Sci. Nat. Univ. Sunyatseni* **2016**, *55*, 158–161. https://doi.org/10.13471/j.cnki.acta.snus.2016.04.024.
24. Kang, Z.; Guan, F.; Gong, S. Chapter III: Strata. In *Shenzhen Geology*, 1st ed.; Qi, X., Gong, Y., Eds.; Geological Publishing House: Beijing, China, 2009; pp. 53–99, ISBN 978-7-116-06012-8. (In Chinese)
25. Charvet, J.; Shu, L.S.; Shi, Y.S.; Guo, L.Z.; Faure, M. The building of south China: Collision of Yangtze and Cathaysia blocks, problems and tent ative answers. *J. Southeast Asian Earth Sci.* **1996**, *13*, 223–235. https://doi.org/10.1016/0743-9547(96)00029-3.

26. Zhao, J.H.; Zhou, M.F.; Yan, D.P.; Zheng, J.P.; Li, J.W. Reappraisal of the ages of Neoptroterozoic strata in South China: No connection with the Grenvillian orogeny. *Geology* **2011**, *39*, 299–302. https://doi.org/10.1130/G31701.1.
27. Zhao, G.; Cawood, P.A. Precambrian geology of China. *Precambrian Res.* **2012**, *222–223*, 13–54. https://doi.org/10.1016/j.precamres.2012.09.017.
28. Xu, X.S.; O'Reilly, S.Y.; Griffin, W.L.; Wang, X.L.; Pearson, N.J.; He, Z.Y. The crust of Cathaysia: Age, assembly and reworking of two terranes. *Precambrian Res.* **2007**, *158*, 51–78. https://doi.org/ 10.1016/j.precamres.2007.04.010.
29. Lin, S.; Xing, G.; David, D.W.; Yin, C.; Wu, M.; Li, L.; Jiang, Y.; Chen, Z. Appalachian-style multiterrane Wilson cycle model for the assembly of South China. *Geology* **2018**, *46*, 319–322. https://doi.org/10.1130/G39806.1.
30. Lin, S.; Xing, G.; David, D.W.; Yin, C.; Wu, M.; Li, L.; Jiang, Y.; Chen, Z. Appalachian-style multi-terrane Wilson cycle model for the assembly of South China: REPLY. *Geology* **2018**, *46*, e447–e448. https://doi.org/10.1130/G40331Y.1.
31. Cocks, L.R.M.; Torsvik, T.H. The dynamic evolution of the Palaeozoic geography of eastern Asia. *Earth-Sci. Rev.* **2013**, *117*, 40–79. https://doi.org/10.1016/j.earscirev.2012.12.001.
32. Xian, H.; Zhang, S.; Li, H.; Xiao, Q.; Chang, L.; Yang, T.; Wu, H. How did South China connect to and separate from Gondwana? New paleomagnetic constraints from the Middle Devonian red beds in South China. *Geophys. Res. Lett.* **2019**, *46*, 7371–7378. https://doi.org/10.1029/2019GL083123.
33. Metcalfe, I. Gondwana dispersion and Asian accretion: Tectonic and palaeogeographic evolution of eastern Tethys. *J. Southeast Asian Earth Sci.* **2013**, *66*, 1–33. https://doi.org/10.1016/j.jseaes.2012.12.020.
34. Domeier, M.; Torsvik, T.H. Plate tectonics in the late Paleozoic. *Geosci. Front.* **2014**, *5*, 303–350. https://doi.org/10.1016/j.gsf.2014.01.002.
35. Metcalfe, I. Palaeozoic and Mesozoic tectonic evolution and palaeogeography of East Asian crustal fragments: The Korean Peninsula in context. *Gondwana Res.* **2006**, *9*, 24–46. https://doi.org/10.1016/j.gr.2005.04.002.
36. Matthews, K.J.; Maloney, K.T.; Zahirovic, S.; Williams, S.E.; Seton, M.; Müller, R.D. Global plate boundary evolution and kinematics since the late Paleozoic. *Global Planet. Change* **2016**, *146*, 226–250.
37. Cao, W.C.; Zahirovic, S.; Flament, N.; Williams, S.; Golonka, J.; Müller, R.D. Improving global paleogeography since the late Paleozoic. *Biogeosciences* **2017**, *14*, 5425–5439.
38. Müller, R.D.; Cannon, J.; Qin, X.; Watson, R.J.; Gurnis, M.; Williams, S.; Pfaffelmoser, T.; Seton, M.; Russel, S.H.J.; Zahirovic, S. Gplates: Building a virtual Earth through deep time. *Geochem. Geophys. Geosystems* **2018**, *19*, 2243–2261.
39. Ren, J. On the geotectonics of southern China. *Acta Geol. Sin.* **1991**, *4*, 111–130. https://doi.org/10.1111/j.1755-6724.1991.mp4002001.x.
40. Ren, J.S.; Niu, B.G.; He, Z.J.; Xie, G.L.; Liu, Z.G. Tectonic framework and geodynamic evolution of eastern China. In *The Lithospheric Texture and Tectonic-Magmatic Evolution of the Eastern China*; Ren, J.S., Yang, W.R., Eds.; Atomic Energy Publishing House: Beijing, China, 1998; pp. 1–12. (Chinese with English abstract)
41. Shu, L.S.; Faure, M.; Wang, B.; Zhou, X.M.; Song, B. Late Palaeozoic–Early Mesozoic geological features of South China: Response to the Indosinian collision events in South Asia. *Comptes Rendus Geosci.* **2008**, *340*, 151–165. https://doi.org/10.1016/j.crte.2007.10.010.
42. Charvet, J.; Shu, L.S.; Faure, M.; Choulet, F.; Wang, B.; Lu, H.; Le Breton, N. Structural development of the Lower Paleozoic belt of South China: Genesis of an intracontinental orogen. *J. Southeast Asian Earth Sci.* **2010**, *39*, 309–330. https://doi.org/10.1016/j.jseaes.2010.03.006.
43. Lin, S.; Wang, L.; Xiao, W.; Xing, G.; Niu, Z.; Zhao, X.; Yin, C.; Zhang, S.; Liu, H. The early Paleozoic Wuyi-Yunkai orogeny in South China: A collisional orogeny with a major lag in time between onset of collision and peak metamorphism in subducted continental crust. In *Supercontinents, Orogenesis and Magmatism*; Nance, R.D., Strachan, R.A., Quesada, C., Lin, S., Eds.; Special Publications 542; The Geological Society: London, UK, 2024; pp. 619–641.
44. Xu, H.H.; Wang, Y.; Tang, P.; Fu, Q.; Wang, Y. Discovery of Lower Devonian plants from Jiangxi, South China and the pattern of Devonian transgression after the Kwangsian Orogeny in the Cathaysia Block. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* **2019**, *531*, 108982. https://doi.org/10.1016/j.palaeo.2018.11.007.
45. Chen, J.F.; Foland, K.A.; Xing, F.M.; Xu, X.; Zhou, T.X. Magmatism along the southeast margin of the Yangtze block: Precambrian collision of the Yangtze and Cathaysia blocks of China. *Geology* **1991**, *19*, 815–818. https://doi.org/10.1130/0091-7613(1991)019<0815:MATSMO>2.3.CO;2.
46. Liu, S.F.; Heller, P.L.; Zhang, G.W. Mesozoic basin development and tectonic evolution of the Dabieshan orogenic belt, central China. *Tectonics* **2003**, *22*, 1038. https://doi.org/10.1029/2002TC001390.
47. Liu, S.F.; Steel, R.; Zhang, G.W. Mesozoic sedimentary basin development and tectonic implication, northern Yangtze Block, eastern China: Record of continent-continent collision. *J. Southeast Asian Earth Sci.* **2005**, *25*, 9–27. https://doi.org/10.1016/j.jseaes.2004.01.010.
48. Cai, J.X.; Zhang, K.J. A new model for the Indochina and South China collision during the Late Permian to the Middle Triassic. *Tectonophysics* **2009**, *467*, 35–43. https://doi.org/10.1016/j.tecto.2008.12.003.
49. Faure, M.; Lepvrier, C.; Nguyen, V.V.; Vu, T.V.; Lin, W.; Chen, Z.C. The South China block-Indochina collision: Where, when, and how? *J. Southeast Asian Earth Sci.* **2014**, *79*, 260–274. https://doi.org/10.1016/j.jseaes.2013.09.022.
50. Faure, M.; Lin, W.; Chu, Y.; Lepvrier, C. Triassic tectonics of the southern margin of the South China Block. *Comptes Rendus Geosci.* **2016**, *385*, 5–14. https://doi.org/10.1016/j.crte.2015.06.012.

51. Faure, M.; Lin, W.; Chu, Y.; Lepvrier, C. Triassic tectonics of the Ailaoshan Belt (SW China): Early Triassic collision between the South China and Indochina Blocks, and Middle Triassic intracontinental shearing. *Tectonophysics* **2016**, *683*, 27–42. https://doi.org/10.1016/j.tecto.2016.06.015.
52. Qiu, L.; Yan, D.P.; Yang, W.X.; Wang, J.B.; Tang, X.L.; Ariser, S. Early to Middle Triassic sedimentary records in the Youjiang Basin, South China: Implications for Indosinian orogenesis. *J. Southeast Asian Earth Sci.* **2017**, *141*, 125–139. https://doi.org/10.1016/j.jseaes.2016.09.020.
53. Xu, Q.; Liu, S.; Wang, Z.; Zhang, B. Provenance of the East Guangdong Basin and Yong'an Basin in southeast China: Response to the Mesozoic tectonic regime transformation. *J. Southeast Asian Earth Sci.* **2019**, *185*, 104024. https://doi.org/10.1016/j.jseaes.2019.104024.
54. Zhou, X.M.; Sun, T.; Shen, W.Z.; Shu, L.S.; Niu, Y.L. Petrogenesis of Mesozoic granitoids and volcanic rocks in South China: A response to tectonic evolution. *Episodes* **2006**, *29*, 26–33. https://doi.org/10.18814/EPIIUGS/2006/V29I1/004.
55. Cao, M.; Zhao, X.; Xing, G.; Fan, F.; Yu, M.; Duan, Z.; Chu, P.; Chen, R. Tectonic transition from subduction to retreat of the palaeo-Pacific plate: New geochemical constraints from the late Mesozoic volcanic sequence in eastern Fujian Province, SE China. *Geol. Mag.* **2021**, *158*, 1074–1108. https://doi.org/10.1017/S0016756820001156.
56. Zhou, D.; Sun, Z.; Chen, H.Z.; Xu, H.H.; Wang, W.Y.; Pang, X.; Cai, D.S.; Hu, D.K. Mesozoic palaeogeography and tectonic evolution of South China Sea and adjacent areas in the context of Tethyan and Paleo-Pacific interconnections. *Isl. Arc* **2008**, *17*, 186–207. https://doi.org/10.1111/j.1440-1738.2008.00611.x.
57. Ma, Y.S.; Chen, H.; Wang, G. *Sequence Stratigraphy and Palaeogeography of South China*; Science Press: Beijing, China, 2009. (In Chinese)
58. Liu, N.; Jiang, B.; Zhou, X.; Zhou, W. Detrital provenance of the Lower Jurassic Jinji Formation and its constraints to the Early Jurassic geodynamic background of South China. *Geol. J. China Univeristies* **2018**, *24*, 65–76. (In Chinese with English abstract) https://doi.org/10.16108/j.issn1006-7493.2017047.
59. Shu, L.S.; Zhou, X.M.; Deng, P.; Wang, P.; Jiang, S.Y.; Yu, J.H.; Zhao, X.X. Mesozoic tectonic evolution of the Southeast China Block: New insights from basin analysis. *J. Southeast Asian Earth Sci.* **2009**, *34*, 376–391. https://doi.org/10.1016/j.jseaes.2008.06.004.
60. Li, J.; Zhang, Y.; Dong, S.; Johnston, S.T. Cretaceous tectonic evolution of South China: A preliminary synthesis. *Earth-Sci. Rev.* **2014**, *134*, 98–136. https://doi.org/10.1016/j.earscirev.2014.03.008.
61. Yu, X.; Hu, J.; Li, W.; Liu, K.; Hao, R. Timing of the initiation and duration of the Cretaceous extensional regime in South-east China: Constraints from growth strata in terrigenous basins. *Depos. Rec.* **2023**, *10*, 4–32. https://doi.org/10.1002/dep2.250.
62. Lu, Y.C.; Sun, J.Z. An investigation on geomorphology and quaternary deposition for activity of the Shenzhen Fault Zone, Guangdong Province. *Seismol. Geol.* **1991**, *13*, 138–146. (In Chinese with English abstract)
63. Kang, Z.; Guan, F. Chapter IV: Quaternary Geology. In *Shenzhen Geology*, 1st ed.; Qi, X., Gong, Y., Eds.; Geological Publishing House: Beijing, China, 2009; pp. 100–120, ISBN 978-7-116-06012-8. (In Chinese)
64. Shenzhen Platform for Common Geospatial Information Services. Shenzhen City Map 2019, Scale 1 : 159 000. Available online: https://guangdong.tianditu.gov.cn/shenzhen/bzmap (accessed on 26 September 2024)
65. Wang, X.; Chen, X. *Stratigraphic Division and Correlation of Each Geological Period in China*; Geological Publishing House: Beijing, China, 2005. (In Chinese)
66. Zhang, R.; Pojeta, J., Jr. New bivalves from the Datang Stage, Lower Carboniferous, Guangdong Province, China. *J. Paleontol.* **1986**, *60*, 669–679. https://doi.org/10.1017/S0022336000022198.
67. Wang, Y.; Popa, M.; Yang, X.; Wu, X. A new record of Bennettitalean flower (*Williamsonia*) from the Lower Jurassic in southern China. In Proceedings of the Program and Abstracts of the 10th European Palaeobotany & Palynology Conference, Dublin, Ireland, 12–17 August 2018; p. 60.
68. Wang, Y.; Popa, M.E.; Wu, X.; Yang, X.; Zhou, N.; Duan, W. A new Bennettitalean Flower from the Jurassic in Southern China. In Proceedings of the Abstracts of the 1st Asian Palaeontological Congress, Beijing, China, 17–19 November 2019, pp. 173–174.
69. Chen, J.H. Liassic bivalve fossils from Mt. Jinji of Guangdong. *Acta Palaeontol. Sin.* **1982**, *21*, 404–416. (In Chinese with English abstract)
70. Wang, Y.; Smith, P.L. Sinemurian (Early Jurassic) ammonite fauna from the Guangdong region of southern China. *J. Paleontol.* **1986**, *60*, 1075–1085. https://doi.org/10.1017/S0022336000022605.
71. Yin, J.; Yao, H.; Sha, J. First record of the Early Jurassic *Lupherella* fauna (Bivalvia) in eastern Guangdong, southeastern China. *N. Z. J. Geol. Geophys.* **2004**, *47*, 321–326. https://doi.org/10.1080/00288306.2004.9515058.
72. He, G.; Li, Z. Early Jurassic ammonites from Fenghuangwen to Shengyong areas of Hong Kong. In *Paleontology and stratigraphy of Hong Kong*; Li, Z., Chen, J., He, G., Eds..; Science Press: Beijing, China, 1997; pp. 104–120. (In Chinese)
73. Tse, T.K.; Pittman, M.; Chang, M.M. A specimen of *Paralycoptera* Chang & Chou 1977 (Teleostei: Osteoglossoidei) from Hong Kong (China) with a potential Late Jurassic age that extends the temporal and geographical range of the genus. *PeerJ* **2015**, *3*, e865. https://doi.org/10.7717/peerj.865.
74. Zhao, Z.K.; Wang, Q.; Zhang, S.K. *Palaeovertebrata Sinica Vol II: Amphibians, Reptilians and Avians; Fascicle 7 (Serial no.11): Dinosaur Eggs*; Science Press: Beijing, China, 2015. (In Chinese)
75. Zhu, X.F.; Fang, K.Y.; Wang, Q.; Lu, X.H.; Wu, W.Q.; Du, Y.L.; Huang, Z.Q.; Wang, X.L. The first Stalicoolithus shifengensis discovered in a clutch from the Sanshui Basin, Guangdong Province. *Vert. PalAsiatica* **2019**, *57*, 77–83. https://doi.org/10.19615/j.cnki.1000-3118.180110.

76. Zhao, Z. Microstructure of dinosaur egg fossils in Nanxiong, Guangdong Province (I)—Also on the classification of dinosaur egg fossils. *Vert. PalAsiatica* **1975**, *13*, 105–117. (In Chinese)
77. Zhao, Z.; Ye, J.; Li, H.; Zhao, Z.; Yan, Z. Extinction of the dinosaurs across the Cretaceous-Tertiary boundary in Nanxiong Basin, Guangdong Province. *Vert. PalAsiatica* **1991**, *29*, 1–20.
78. Fang, X.; Zhang, Z.; Zhang, X.; Lu, L.; Han, Y.; Li, P. Fossil eggs from the Heyuan basin, east-central Guangdong, China. *Geol. Bull. China* **2005**, *24*, 682–686. (In Chinese with English abstract)
79. Huang, Z.G.; Li, P. *Geomorphology in Shenzhen*; Guangdong Science and Technology Press: Guangzhou, China, 1983. (In Chinese)
80. Zhang, Y.; Yu, S. Palynological assemblages of late Quaternary from the Shenzhen region and its palaeoenvironment evolution. *Mar. Geol. Quat. Geol.* **1999**, *19*, 109–114. (Chinese with English abstract)
81. Jin, J.; Wang, X.; Liao, W. Quaternary stratigraphy and ancient vegetation characteristics of the Shenzhen area. In Proceedings of the Supplementary Abstracts of the 3rd Cross-Strait, Hong Kong, Macau and World Symposium on Geological Sciences, Hong Kong, China, 19–22 December 2002; pp. 50–53. (In Chinese)
82. Dong, H.M.; Song, Y.G.; Chen, T.; Zhao, J.B.; Yu, L.P. Geoconservation and geotourism in Luochuan Loess National Geopark, China. *Quat. Int.* **2014**, *334–335*, 40–51.
83. Dong, Y.; Cao, X.J.; Guo, X.Y. Protection of geoheritages resources in China. *Chin. J. Geol. Hazard Control.* **2010**, *21*, 114–117. (In Chinese with English abstract)
84. Dong, Y.; Cao, X.J.; Fan, X.; Yang, G.; Zhang, Z.X.; Fang, J.H.; Chen, X.R.; Zhang, Z.J.; Ji, S.A. Investigation of important palaeontological fossil sites and geological relics in China. *Hydrogeol. Eng. Geol.* **2010**, *37*, 141–142. (In Chinese)
85. Li, L.R.; Jiang, J.J.; Wang, W. *China's Geological Heritage Resources and Their Management*; China Land Publishing House: Beijing, China, 2004; ISBN 7800975096. (In Chinese)
86. Collatera, A.; Sorbini, C.; Farina, S.; Granata, V.; Marchetti, L.; Frassi, C.; Angeli, L.; Bianucci, G. Reviewing the palaeontological and palaeoenvironmental heritage of the Monti Pisani Massif (Italy): A compelling history of Animals, Plants and Climates through three geological Eras. *Geosciences* **2023**, *13*, 332.
87. Dowling, R.K.; Newsome, D. *Geotourism*; Elsevier/Heinemann Publishers: Oxford, UK; Burlington, MA, USA, 2006; ISBN 13 978-0-7506-6215-4.
88. Newsome, D. The need for a planning framework to preserve the wildness of Sibayak Volcano, north Sumatra. In *Volcano & Geothermal Tourism: Sustainable Georesources for Leisure and Recreation*; Erfurt-Cooper, P., Cooper, M., Eds.; Earthscan: London, UK, 2010; pp. 131–141.
89. Ng, C.Y.; Fung, L.W.; Newsome, D. Hong Kong Geopark. In *Global Geotourism Perspectives*; Dowling, R., Newsome, D. Eds.; Goodfellow Publishers: Oxford, UK, 2010; pp. 179–191.
90. Brilha, J. Inventory and quantitative assessment of geosites and geodiversity sites: A review. *Geoheritage* **2018**, *8*, 119–134.