THE FLINDERS RANGES

D.J. PEISLEY*
Cave Exploration Group (South Australia)

Abstract

The landuse history of the region is outlined and the geology described. Four separate caving areas are identifed and characterised. The palaeontological significance of the Flinders Ranges is indicated and some comments made about the impact of present landuse patterns in the absence of an overall management strategy.

INTRODUCTION

The Flinders Ranges in South Australia are a series of thrusted uplands stretching in a boomerang arc, 500 km long, from Melrose in the south to Mount Hopeless in the north. The Willouran Ranges, although detached, are a related offshoot.

First sighted on 7 March, 1802 by Matthew Flinders from his ship Investigator they were not to be named Flinders Ranges until 1839 by Governor Gawler.

Exploration began in 1840 when Edward John Eyre set out to make his famous trip to King George Sound. On 27 June, 1840 he made this journal entry:

> From our present encampment a very high and pointed hill was visible far to the N.N.W. this from the lofty way in which it towered above the surrounding hills, I named Mount Remarkable.

At that time the area was occupied by several tribes of aborigines, notably the Adjnamutana, who were fearless and jealously guarded the Ranges, obviously due to the relative abundance of food and water.

Within ten years the white European settlers had moved in building homesteads and bringing with them their domestic animals.

The next fifty years saw a great influx of pioneer families, farmers, graziers and miners. They suffered many hardships with lack of medical care, bad roads, slow communications and hostile aborigines.

During the 1870's wheat crops were planted with good returns. Then came the Great Drought. Small holdings and towns which had flourished were deserted and now remain as stark ruins, reminders of shattered dreams. Once fertile soil, which supported many varieties of native grasses and wildflowers, was eroded away.

By the turn of the century a stable industrious population was formed but economic pressures were brought to bear on the farmer who strove to make his land once again fertile and as profitable as possible. Dry and seemingly arid land was seen to be productive with the aids of "scientific farming", by additives to the soil, either organically or chemically. Chemicals were readily available but expensive and sometimes complex in composition. What the farmer needed was cheap, organic and easily available fertilizer. "Farmyard" fertilizers were most readily sought after and farmers who drove to the cities with their produce, re-loaded with horse manure obtained from city stables. This often had to be carted long distances and was not always available in the quantities needed.

* 23 Dorset Street, BRAHAMA LODGE, S.A. 5109.

Bat guano contains appreciable quantites of nitrogen which gives the highest degree of fertilizing power. It was found that one ton of bat guano was equal in manurial value to 21 tons of stable manure! Was it any wonder this was a prize highly sought after?

For forty years one lone prospector (Montague) worked several small guano deposits without great success until Mr W.G. Hardy of Pamatta Station informed him of the Buckalowie Creek caves. A limited liability company named Nitrogen Limited was officially set up on 10 January, 1922 to mine the deposits in Clara St. Dora, buying out Angus Mair owner of the Mairs Cave claim. First estimates on the deposits (sufficient to keep the works at full blast for fifty years) were greatly overestimated.

The search for guano brought to light many caves and it was a report of the activities in an early Mining Review that inspired the first official Cave Exploration Group of South Australia (C.E.G.S.A.) trip in December, 1955.

GEOLOGY

The topography of the Flinders Ranges is the result of sedimentation, orogenisis and subsequent erosion of what is termed the Adelaide Geosyncline. The time interval represented in this area spans the crucial Pre-Cambrian-Cambrian boundary which is a major break in the rock record throughout the world. Major faulting or metamorphism is minimal or moderate and enables a relatively uncomplicated history of this area to be determined.

The crystalline basement rocks of Archaean to Late Proterozoic age (1 500 million years ago) were eroded away and deposited in an adjacent long shallow marine trough. Depositional environments ranged from shallow marine (less than 200 m) to marginal marine. Slow subsidence of this trough enabled great thicknesses of sediments to be deposited, in some places to 10 km deep. Table 1 gives the broad outline of deposits and the approximate depositional areas.

The oldest sediments in the sequence are the Callanna Beds (inferred age 1 400 million years) consisting mainly of quartzites, siltstones, stromatolitic carbonates and basic volcanics. These lie unconformably over the crystalline basement rocks and outcrop near Mount Painter and Arkaroola.

The Burra Group, which began approximately 900 million years ago, is characterised by conglomerates, quartzites, dolomites and sandstones which show mud-cracks, salt-casts and cross-bedding suggesting tidal flat or fluvial environment.

The Skillogalee Dolomite contains distinctive stromatolites and some black cherts containing algal filaments.

Two important glacial periods are represented by the Sturtian Tillites (over 5 000 m thick) which underly the shales and carbonates of the Umberatana Group and the Marinoan Tillites (over 6 000 m thick) which underly the Wilpena Group. Radiometric dating suggests 660 to 680 million years for the Marinoan Tillites and as they occur over a very large area they act as key marker beds.

The Wilpena Group, consisting of sandstones, quartzites and siltstones, completes the Adelaidean where warm to tropical climate conditions prevailed. The world famous Ediacara fossils occur in the Upper Wilpena Group in the Upper Pound Quartzite.

A period of erosion, followed by basin subsidence and subsequent sea transgression led to extensive carbonate deposition during the Cambrian Period with

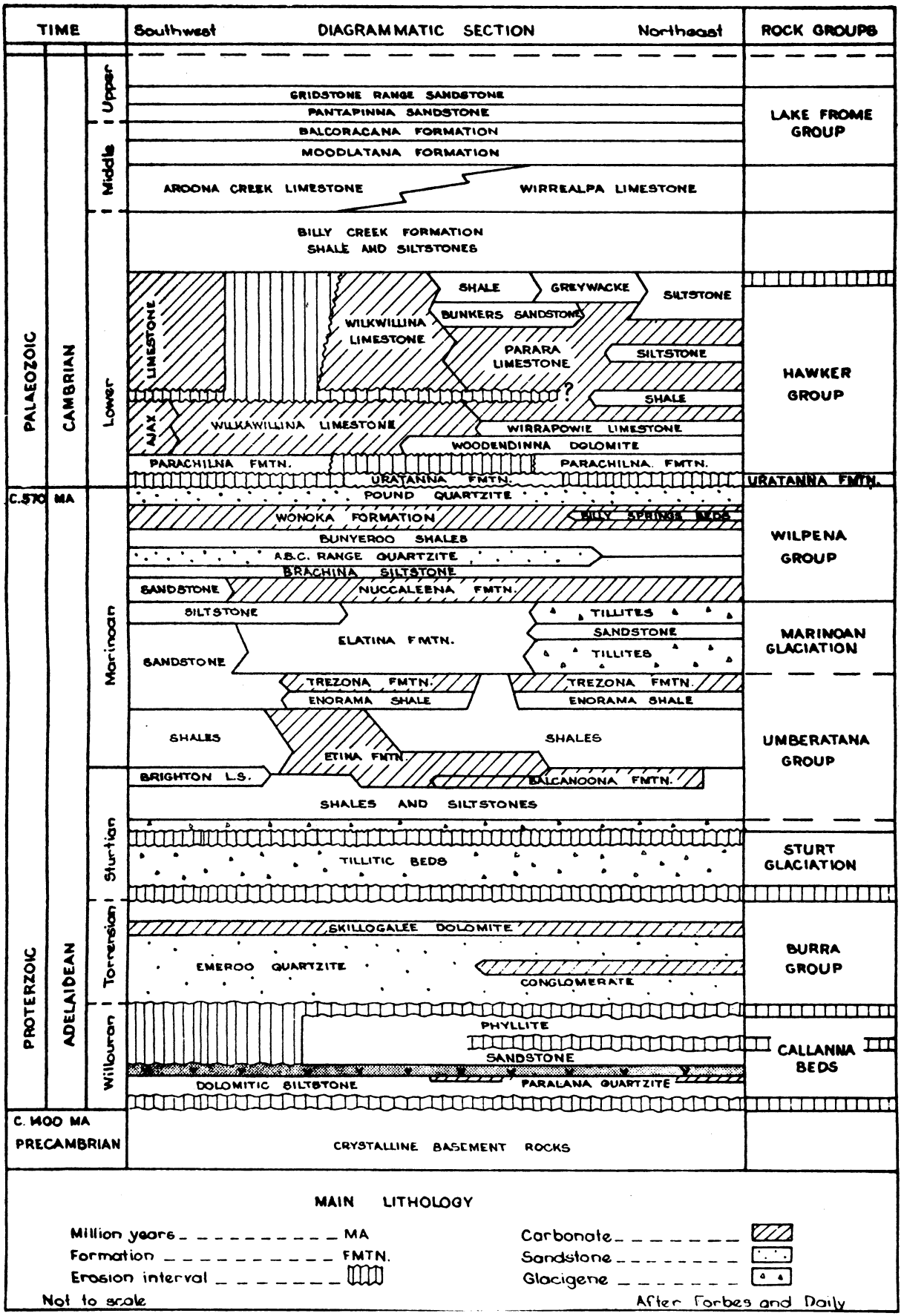

Table 1. Sedimentation - Adelaide Geosyncline.

the Uratanna and Parachilna Formations rich in trace fossils occurring in the Lower Cambrian Period. Shelf deposits such as the lighter coloured Ajax and Wilkawillina limestones reflect tidal environments grading to warm clear waters of the neritic zone. Dark coloured limestones appear to reflect increased water depth. The Hawker Group includes the Woodendinna Dolomite and the Wilkawillina and Parara Limestones.

Fossil fauna becomes increasingly varied including Archaeocyatha, trilobites, hyolothids, brachiopods, gastropods and stromatolites.

Sedimentation gradually exceeded subsidence and the carbonates gave way to clastic sediments of the Billy Creek Formation containing trilobites and gastropods, followed by marginal marine "red bed" sedimentation. The final capping sediments of the Lake Frome Group are similar carbonate clastics, the final phase being the Gridstone Range Sandstone.

Conversion of this thick bed of sediments to a mountain range took place about 520 to 460 million years ago during the Late Cambrian to Early Ordoivician Period. Lateral compression of the trough by the enframing basement landmasses produced the basically concentric fold pattern, typified by narrow anticlines separated by broad, almost flat-bottomed synclines. Wilpena Pound is a classical example which is most easily seen from the air. Structural complications occur due to the "plastic" injection of brecciated basement material contemporaneous with sedimentation, forming the "diapirs" of the Flinders Ranges. A very long period of erosion followed and renewed lateral basement compression in the Tertiary Period (65 to 2 million years ago) raised the sediments again allowing weathering agents to etch out the present day awe-inspiring topography.

THE CAVES

This large area has relatively few known caves and they occur in the carbonate sediments of dolomite and limestones. Cave development is impeded by the rapid run-off with little seepage essential to the making of large cave systems. For simplification I have divided the area into six regions where the greatest number of caves occur. For separate descriptions of these caves see C.E.G.S.A.'s Occassional Paper Number 5, pages 34-38.

The Lower Flinders contains five known caves (F-1, F-2, F-20, F-21 and F-22). F-1 and F-2, at Melrose, occur in local sandy pink and grey dolomite of the Umberatana Group (? Brighton Limstone equivalent) with thin interbeds of granule sandstone. The term "Blowhole" which is locally applied to F-1 is misleading as there appears to be no appreciable air movement.

F-21 and F-22 are interesting as they occur in the Emeroo quartzite of the Burra Group and follow an obvious jointing pattern.

F-20, apparently an isolated incidence of a cave, is formed in oolitic limestone of the Etina Formation and is situated in the basin of a syncline. A joint-controlled cave, with some decoration, it has an unusually high humidity.

The Buckalowie area has four known caves (F-3, F-4, F-27 and F-28) all having vertical entrances. This has proved the most popular caving venue in the Flinders. The caves are contained in a narrow steeply-dipping (85° E) outcrop of dolomite (suggested correlation with Brighton Limestone), which is bounded by easily weathered shales. All these caves were mined for guano and F-4 has had an adit driven for easier access. F-3 and F-4 both had large workings. In F-3, this almost vertical dip has a strong influence on the development of

the cave where the walls are frequently the bedding planes. During the 1960's a palaeontological dig was undertaken in F-3 to remove bone material. This will be commented on later. F-4 has some particularly beautiful calcite crystals which unfortunately have been subject to some abuse by rock collectors. F-27 and F-28 are both 10 m deep fissures ending in rubble chokes which, in spite of enthusiastic investigations, failed to develop further.

The Holowilena Syncline contains five caves (F-5, F-6, F-7, F-14 and F-17) in sandy oolitic limestones of the Etina Formation (Umberatana Group) bounded by dolomitic Shales of the Enorama Group. All the caves are formed by solution following the joints and planes creating extensive mazes of passages. The most extensive of these are F-5 and F-7 and, although all were mined for guano, these proved the most profitable. Remnants of mining days still remain with screens, buckets, explosives and shovels being left behind (the explosives have now been removed).

The Central Flinders area has isolated occurrences of caves and although bats occur in some of them only F-8 has been mined for guano. There are seven known caves (F-8, F-13, F-15, F-16, F-29 and two unnumbered caves). F-8 is quite extensive, mazelike and very dusty, occurring in Wilkawillina Limestone of the Hawker Group which is rich in Archaeocyathids and brachiopods. F-15 and F-16 occur in the Trezona Formation of the Umberatana Group which underlies the Marinoan Glacial sequence hence making it a key marker bed. F-29 and the two unnumbered caves occur in Brachina Gorge in flaggy limestone of the Wonoka Formation of the Wilpena Group interbedded with grey calcareous shale. They are joint-controlled, following bedding planes and at present are roosts for bats. F-13 also has bats and hopefully will remain a safe haven as the entrance is not easily discernible. It occurs in dark flaggy Parara Limestone of the Hawker Group interbedded with shales.

Eight caves occur in the Narrina area (they are F-10, F-11, F-12, F-18, F-19, F-23, F-24, and one unnumbered cave). F-10 is formed in a synclinal basin in oolitic limestone and pale grey dolomite of the Balcanoona Formation (Brighton Limestone equivalent). A sporty four-wheel drive track leads to this cave of exceptional dog-tooth spar calcite decoration. The unnumbered cave occurs in the Nuccaleena Formation of the Wilpena Group, a flaggy dolomite, overlain by reddish Brachina Shales and is encountered on this same track. The rest of the caves occur in Cambrian fossiliferous Wilkawillina Limestone of the Hawker Group.

F-11 is of particular interest having permanent water which lies above the watertable. It has been dived and recently the South Australian Museum expressed interest in the cave to ascertain if any life was present, in particular the *Milyeringa veritas*, Blind Gudgeon or Blind Cave Fish which can be found in Western Australia. Three museum representatives, three divers, a teacher and the author visited the cave in May 1978. The divers took capture nets and bottles to collect anything of interest and to take water samples. A thermometer was taken to the bottom and this registered 22°C. Cave air temperature was 23°C and the very high relative humidity was estimated at 85-90%. Water samples were obtained from a local creekbed for comparison (Table 2), and there appears no substantial difference in the breakdown. After analysis John Glover the Curator of Ichthyology, South Australian Museum, thought that although no lifeforms were found it was possible they could survive under present conditions. It was disappointing not to have found anything, although we expected it, and we can quell future rumours with confidence.

The Northern Flinders encompasses the Arkaroola-Wooltana area and westwards to Lake Torrens. There are numerous small holes not yet explored or given

Chemical composition	Narinna Lake Cave		Brachina Creek	
	Milligrams per litre mg/L	Milliequivalents per litre me/L	Milligrams per litre mg/L	Milliequivalents per litre me/L
Cations				
Calcium (Ca)	160	8.0	108	5.4
Magnesium (Mg)	78	6.4	78	6.4
Sodium (Na)	260	11.3	260	11.3
Potassium (K)	18	0.5	5	0.1
Anions				
Carbonate (CO_3)	nil	nil	nil	nil
Bicarbonate (HCO_3)	391	6.4	348	5.7
Sulphate (SO_4)	288	6.0	206	4.3
Chloride (Cl)	525	14.8	500	14.1
Nitrate (NO_3)	nil	nil	nil	nil
	TOTALS AND BALANCE		TOTALS AND BALANCE	
	Cations me/L	Anions me/L	Cations me/L	Anions me/L
	26.2	27.2	23.2	24.1
	diff.Δ 1.0 sum Σ 53.4 % $\left(\frac{\Delta \times 100}{\Sigma}\right)$ 1.9		diff.Δ 0.9 sum Σ 47.3 % $\left(\frac{\Delta \times 100}{\Sigma}\right)$ 1.8	
Derived and other data		mg/L		mg/L
Conductivity (E.C.) µS/cm at 25° C	2500		2260	
Total dissolved solids (based on E.C.)		1450		1310
Total hardness calc. as $CaCO_3$		721		591
Carbonate hardness calc. as $CaCO_3$		320		285
Non-carbonate hardness calc. as $CaCO_3$		401		306
Total alkalinity calc. as $CaCO_3$		320		285
Sodium adsorption ratio	4.2		4.7	

Table 2. Water analysis report - comparison of water samples.

Proceedings of 12th Conference of the ASF 1979

locations in the Arkaroola area. F-9 and F-26 are the two caves known in C.E.G.S.A.'s records. F-26 occurs in flaggy dolomite of the Wonoka Formation (Wilpena Group). This formation has been subject to large scale slumping which can be seen in several places in the Flinders. F-9 is the best known cave of this area occurring in Balcanoona Dolomite of the Umberatana Group. A spectacular vertical entrance drops 70 m to the floor of the cave where it bells out into a large chamber. Reserves of guano were estimated to be over 900 tons in 1924 before mining commenced. A mummified specimen of *Macroderma gigas*, a carnivorous bat now extinct in the Flinders, was found in 1925.

Some mention must be made of the Yourambulla Caves which are located near Hawker. They are essentially Aboriginal rock shelters where painting can be seen. They occur in Pound Quartzite and have been subject to conchoidal weathering and are of archaeological interest rather than speleological interest.

FOSSILS

There are several caves that have recorded incidences of fossils, the most notable being F-3. An extensive dig was begun in the 1960's by P. Rose but unfortunately it was never finished and has since been inundated by the 1974 floods. Recognised species that have been recovered include a predominance of carnivores such as *Thylacinus*; *Thylacoleo*, marsupial "lion"; *Sarcophilus*, Tasmanian Devil, *Dasyurus* sp., tiger cat; and numerous rodents. Kangaroo, wallaby and some bird bones have also been identified and *Trichosurus*, the Brush-tailed Possum have been found in several caves.

Other fossils unearthed in open sites include the famous Ediacara trace fossils. This fauna, preserved by sand burial on a muddy shoreline, evolved in a protected, low-energy "lagoon" type of environment. They were found in 1947 by a government geologist. Most of the fauna consists of coelenterates (jellyfish) and worms. Coelenterates make up nearly 70% of the fossils discovered and include *Cyclomedusa*, jellyfish and *Pennatulaceans*, sea pens.

Dickinsonia costata and *Spriggina floundersi* are polychaete worms (segmented worms) and make up 25% of the faunal assemblage.

Trace fossils from the Cambrian Period include the U-shaped burrows of the *Diplocraterion* and Trilobite tracks. Many species of Trilobite include *Redlichia*, *Balcoracania flindersi* and *Balcoracania dailyi*.

The phylum Archaeocyatha lasted for only a few tens of millions of years during the Lower to Middle Cambrian Period (a short time geologically speaking) but many genera have been recognised.

Post-Cambrian vertebrate fossils are not common but the Lake Callabonna area north of the Flinders Ranges has yielded *Diprotodon*; *Sthenurus*, giant short-faced kangaroo; *Protemnodon*, giant wallaby; *Phascolonus* giant wombat; and *Genyornis*, giant bird. Species found in other areas include *Nototherium*, *Macroderma* and Dingo. Once unearthed bones deteriorate very quickly and it is possible many have been lost through ignorance of what they might be.

CONCLUSION

The Flinders Ranges have many other aspects equally as interesting as those already mentioned. More than 100 000 tourists visit the area each year and mineral exploration companies spent more than $3 million searching for minerals during 1970. Unfortunately this huge influx has left its mark on the natural

drawcards of beautiful scenery, flora and fauna. Tracks have been randomly worn by vechicles, and trees around campsites have been stripped of wood for campfires. Recovery from this barrage is slow or non-existent and further deterioration is imminent unless some form of control can be maintained. The National Parks cover only a small portion and the remainder continues to be subjected to abuse. It is still well worth visiting both for the scenery and for caving and I may be a little optimistic in hoping that in the future we could have a Flinders Ranges National Park.

ACKNOWLEDGMENTS

The advice and help of Mr Neville Pledge and Mr John Glover of the South Australian Museum is gratefully acknowledged, also the assistance of Dr Brian Daily of the Geology Department, University of Adelaide. I would also like to thank Mr Athol Jackson for presenting this paper in my absence and Mr Kevin Mott for drawing up the tables.

REFERENCES

Daily, B. (1976). *The Cambrian of the Flinders Ranges.* Excursion Guide 33A: p. 15-19.

Campana, B. (1958). *The Flinders Ranges.* Geology of South Australia, in Glaessner, M.F. & Parkin, L.W. (Eds). Melbourne University Press.

Coats, R.P. & Blisset, A.H. (1971). Regional and Economic Geology of the Mount Painter Province. *Geol. Surv. S. Aust.*: p. 391-394.

Corbett, D.W.P. (Ed.). (1969). *Natural History of the Flinders Ranges.* Libraries Board of South Australia.

Forbes, B.G. & Coats, R.P. (1976). *Precambrian Geology of the Adelaide Geosyncline.* Excursion Guide 33A: p. 11-15.

Jennings, J.N. (1971). *Karst.* A.N.U. Press, Canberra.

Lewis, I.D. (1976). *South Australian Cave Reference Book.* C.E.G.S.A. Occasional Paper No 5:34-38.

Segnit, R.W. (1932). *Report on Guano Deposits.* Mining Review, Ad. 36: p. 57.