

Rock type

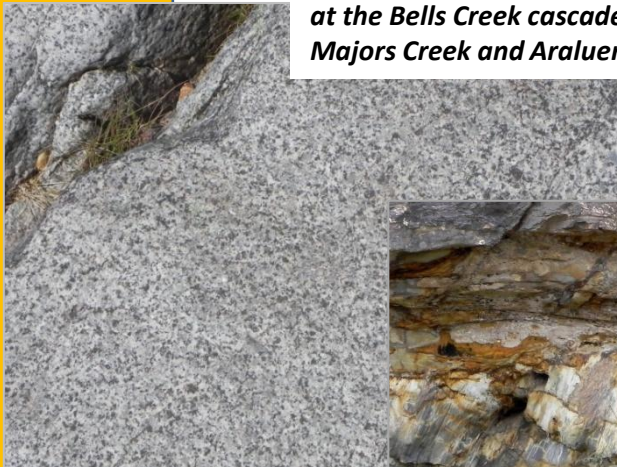
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Rock type

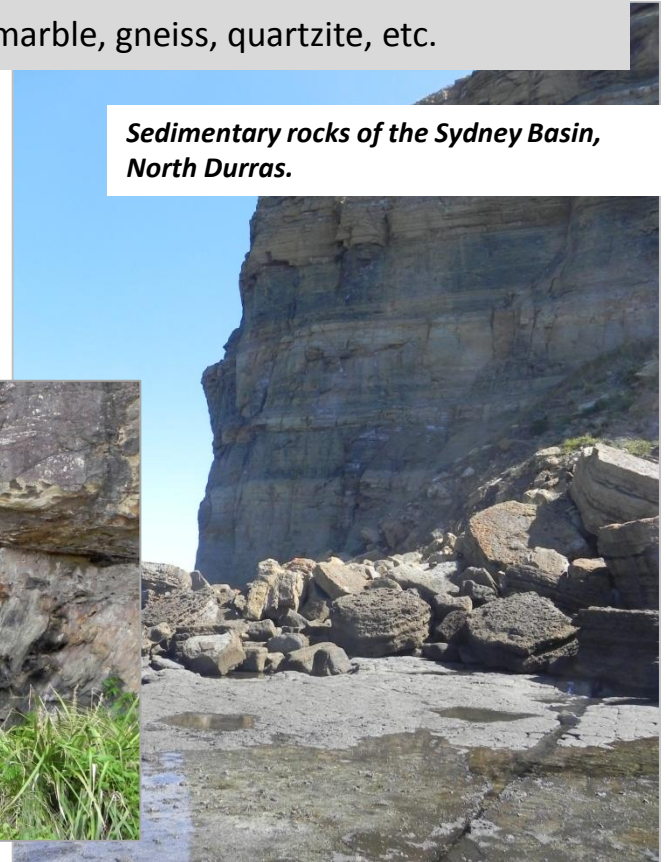
The three broad groups of rocks are -

- 1) Sedimentary rocks – sandstone, limestone, conglomerate, etc.
- 2) Igneous rocks – granite, basalt, andesite, scoria, etc.
- 3) Metamorphic rocks – slate, marble, gneiss, quartzite, etc.

*Igneous rock outcrop of Braidwood Granodiorite
at the Bells Creek cascades between
Majors Creek and Araluen.*



*Sedimentary rocks of the Sydney Basin,
North Durras.*



*Low grade metamorphic rocks
(metasediments - mostly shales and slates)
of the Wagonga Group, Myrtle Beach.*



Sedimentary Rocks

Sedimentary rocks are formed by the accumulation of sediments. There are three basic types of sedimentary rocks:

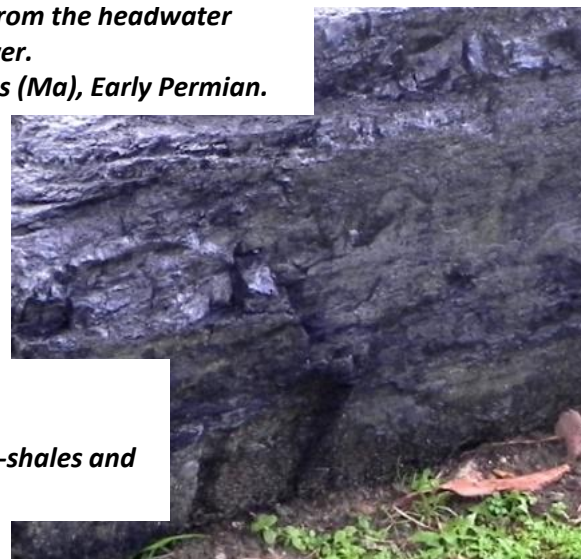
1. **Clastic sedimentary rocks** such as sandstone, breccia, conglomerate, and shale, that are formed from weathering, transport and deposition of mineral and rock fragments derived from erosion of older rocks by water, wind and ice.
2. **Chemical sedimentary rocks** such as rock salt and some limestones, that form when dissolved materials precipitate from solution.
3. **Organic sedimentary rocks** such as coal and some limestones which form from the accumulation of plant or animal debris.

(<http://geology.com>)

*Clyde Coal Measures from the headwater region of the Clyde River.
Age – 300 million years (Ma), Early Permian.*



Unconformity between mostly flat-lying Permian Wasp Head Formation (286-290 Ma) sandstone and the underlying steeply-dipping low grade metamorphic rocks (metasediments -shales and slates) of the Wagonga Group (450 Ma).



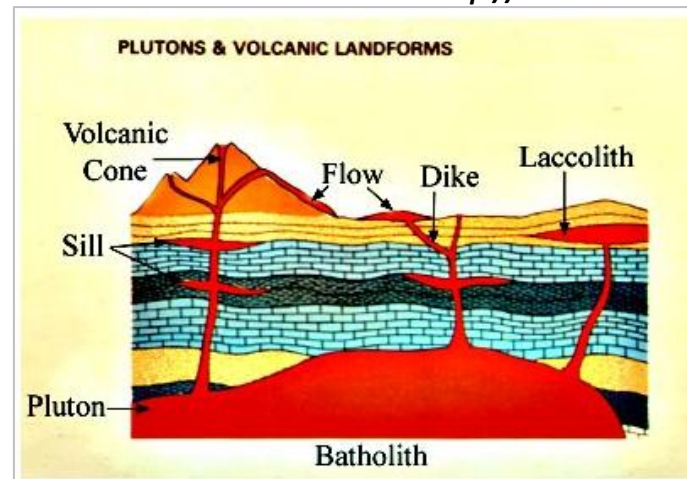
Igneous Rocks

Igneous rocks are formed from the solidification of molten rock. There are two basic types:

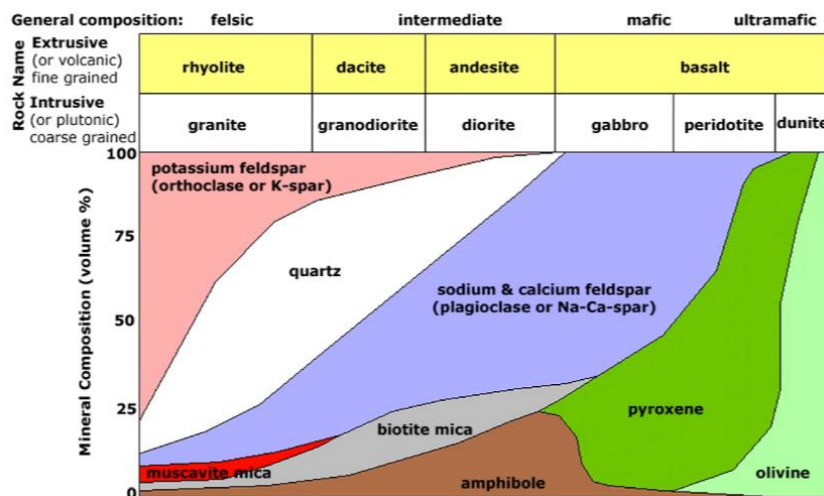
1) **intrusive igneous rocks** such as diorite, gabbro, granite and pegmatite that solidify below Earth's surface; and 2) **extrusive igneous rocks** such as andesite, basalt, obsidian, pumice, rhyolite and scoria that solidify on or above Earth's surface resulting from volcanic eruptions, but also sometimes below sea level.

(<http://geology.com>)

<http://indiana.edu>



Igneous rocks contain many minerals that are often only identified using a microscope and chemical analysis.



Igneous rock classification

<http://geocaching.com>

Dark basalt intruding Moruya Tonalite at Bingi Bingi Point.



Metamorphic Rocks

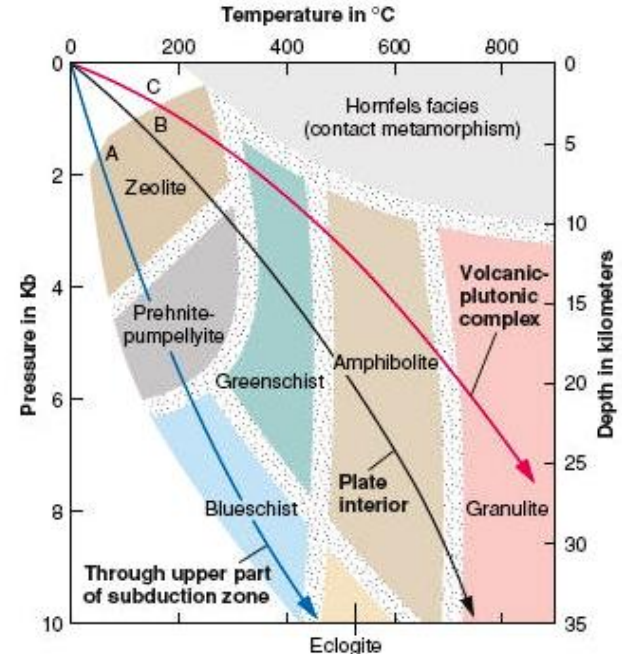
Metamorphic rocks are pre-existing rocks that have been modified by heat, pressure and chemical process usually while buried deep below Earth's surface, sometimes at a subduction zone or other plate collision zone. Exposure to these extreme conditions has altered the mineralogy, texture and chemical composition of the rocks.

There are two basic types of metamorphic rocks:

- 1) **Foliated metamorphic rocks** such as gneiss, schist, phyllite, and slate which have a layered or banded appearance that is produced by exposure to heat and directed pressure.
- 2) **Non-foliated metamorphic rocks** such as marble and quartzite which do not have a layered or banded appearance.

(<http://geology.com>)

Depending on the depth of burial and the temperature, metamorphic rocks can be graded from greenschist facies, to higher grade amphibolite facies and granulite facies.



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Graptolite fossils (white streaks) in deep-water shale.



Adaminaby Group

Sandstone, mudstone, shale, carbonaceous shale, greywacke, chert, quartzite, phyllite, and slate 470 to 445 million years old folded and uplifted at the end of the Benambran Tectonic Cycle, about 444-428 million years ago.

Sedimentary rocks in the Adaminaby Group are widespread across southeastern Australia. They originated during the Ordovician geological period when clay, sand and rock fragments were carried by high energy rivers from rapidly eroding highlands of Gondwanaland, and then cascaded down steep submarine slopes as gravity flows to be deposited on the deep ocean floor, probably more than 4000m deep. The grain size in the sedimentary rocks determines whether they are called mudstone, sandstone, conglomerate, etc.

These sediments were then compacted and consolidated before being folded and uplifted during the two major tectonic episodes 444 – 428 million years ago. In some of the darker carbonaceous shales, graptolite fossils can be found.

Adaminaby Group rocks are well exposed in outcrop in road cuttings along the Kings Highway from Batemans Bay to Nelligen. They can also be seen along the Princes Highway north to Ulladulla, and along the Moruya River road to Araluen.



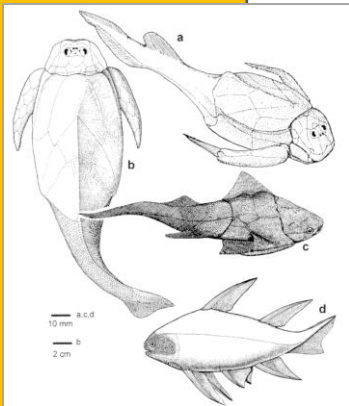
Steeply dipping Ordovician Adaminaby Group siltstones and sandstones, Moruya River road from Moruya to Araluen.

Geology of the Batemans Bay region

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Reconstructions of Devonian placoderm fish found as fossils in NSW far south coast rocks. (Young, 2007)



Merimbula Group

Sandstone, siltstone, slate, and conglomerate of the Devonian Merimbula Group of rocks about 380 million years old are exposed in road cuttings along the steep sections of the Kings Highway between Braidwood and Nelligen near Clyde Mountain and Government Bend. During this geological period the Earth's crust in southeast Australia rifted and there was volcanism and associated erosion and deposition of sediments.



Folded Devonian sandstones, siltstones and slates of the Merimbula Formation exposed in a road cutting on the Kings Highway near Clyde Mountain and Government Bend.

Rock type

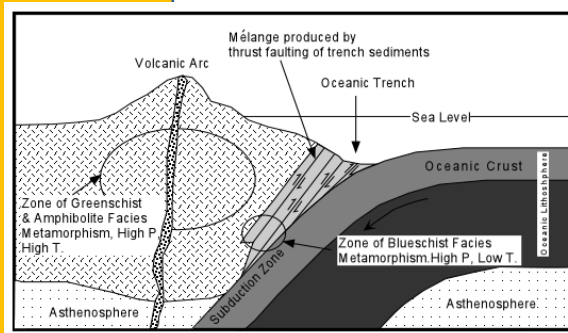
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Narooma – Batemans Bay Accretionary Complex

Sandstone, mudstone, shale, carbonaceous shale, greywacke, chert, quartzite, phyllite, and slate, *about 470 to 445 million years old (Cambrian – Ordovician)*

Rocks in the Narooma – Batemans Bay Accretionary Complex are a complicated association of highly deformed deep marine rocks of the Wagonga and Adaminaby Groups that were deposited in a deep ocean near a subduction zone during the early history of the Lachlan Orogen. Some were buried to depths of up to 15 km at about 300° Centigrade before being uplifted and exposed along the coast when the Tasman Sea rift opened up beginning about 92 million years ago. They are often called a “*mélange*” – a chaotic mixture of blocks and fragments of rock, some of sedimentary origin and some of igneous origin. Some are low grade metamorphic rocks of predominantly lower greenschist facies.

Fergusson & Cox, 2014



Highly folded chert and mudstone of the Narooma Chert, Melville Point near Tomakin.

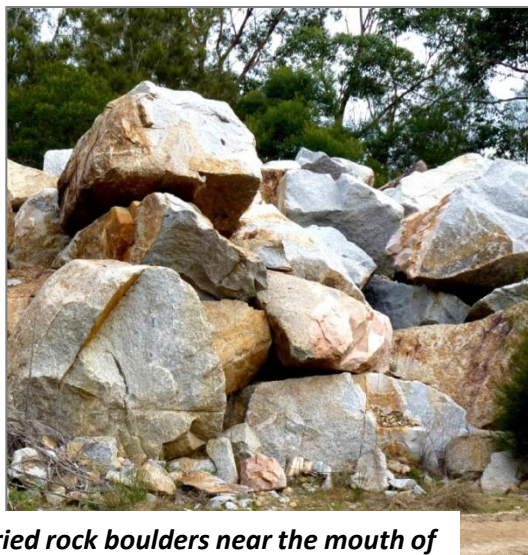
Moruya Tonalite



Moruya Tonalite

The Moruya Tonalite is a 379 million year old (Middle to Late Devonian) igneous rock unit of the Moruya Suite of plutons in the eastern Lachlan Orogen. The Moruya Suite is composed of six north-south-trending elongate plutons at the extreme eastern side of the regional Bega Batholith. Good outcrops are also seen farther south at Bingi Bingi Point and Tuross Heads.

18,000 cubic metres (over 40,000 tonnes) of this rock unit outcropping on the northern bank of the Moruya River were quarried during the 1920's and shipped to provide stone for the construction of the pylons for the Sydney Harbour Bridge.



Quarried rock boulders near the mouth of the Moruya River.



Sydney Harbour Bridge pylon.

Geology of the Batemans Bay region

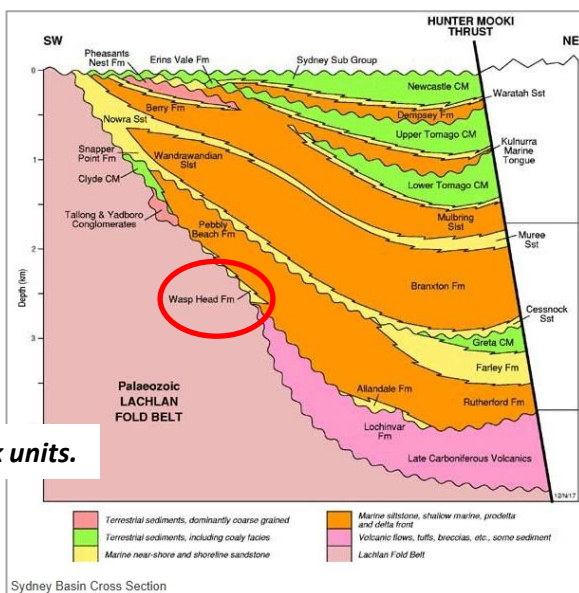
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Sydney Basin rock units.

Wasp Head Formation

The Wasp Head Formation is a shallow marine, fine- to medium-grained sandstone and breccia unit near the base of the Permian – Triassic Sydney sedimentary basin. Age 286 – 290 million years.



The Lower Permian Wasp Head Formation is a 95 metre (approx.) thick unit that was deposited during the transition to a non-glacial period following an earlier glacial event in eastern Australia. The glaciers and icebergs transported “drop stones” into the underlying soft sediments, seen now throughout these early basin sequences.

Photo – Doug Finlayson



Drop stone near Wasp Head.



Photo – Doug Finlayson

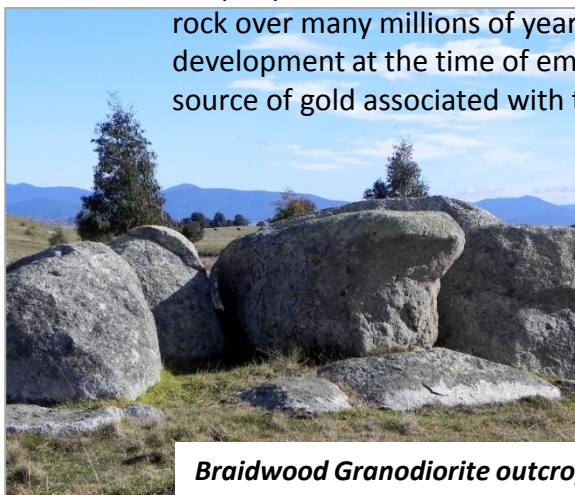
Braidwood Granodiorite



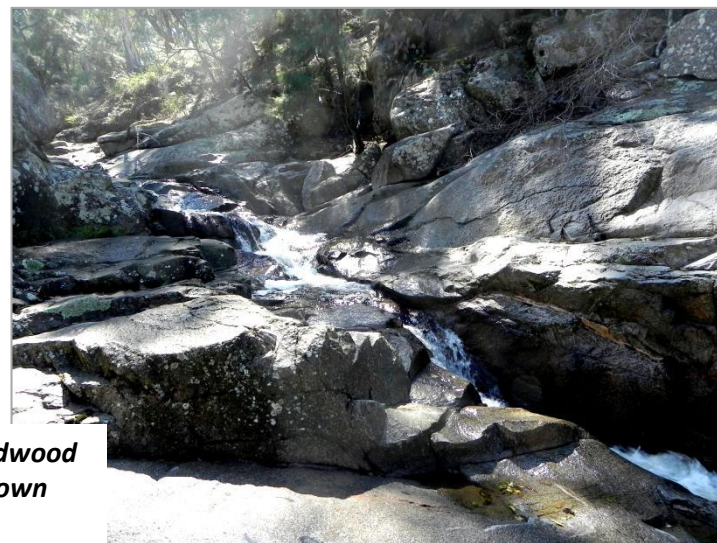
Braidwood Granodiorite

The Early Devonian Braidwood Granite that crops out around the town is a hornblende-biotite granodiorite with an age of 410.8 – 411.3 million years.

The Braidwood Granodiorite is an intrusive igneous rock unit and one of the plutons within the Candelo Supersuite that forms part of the regional Bega Batholith. These plutons would have been emplaced a few kilometres from the Earth's surface from a deeper partial melt source and subsequently exposed by uplift and erosion of overlying rock over many millions of years. Hydrothermal processes and quartz vein development at the time of emplacement of the pluton are considered to be the source of gold associated with the pluton.



Braidwood Granodiorite outcrop near Reidsdale where gold was first discovered in 1851.



Bells Creek cuts through Braidwood Granodiorite as it cascades down towards Araluen.

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Coila Basalt hand sample.
Photo – Doug Finlayson



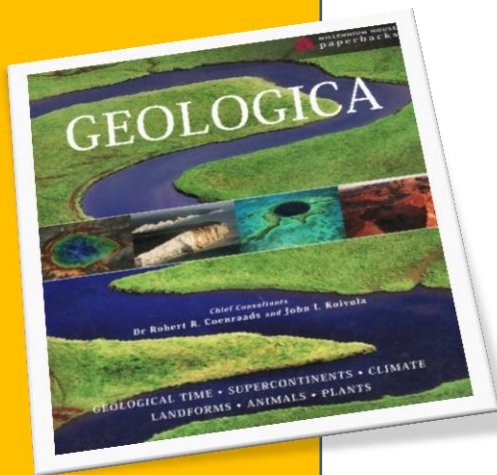
Coila Basalt

Since the Australian continent rifted from Antarctica and started drifting northwards, there have been numerous episodes of volcanism along eastern Australia. They resulted in outcrops of igneous rocks commonly called the Tertiary Basalts. In the Batemans Bay region the Coila Basalt erupted 29.1 million years ago and flowed down river valleys.

The Coila Basalt is an olivine basalt flow of Middle Oligocene age and it occurs as disconnected outcrops between Mogo and Bodalla with a maximum thickness of 33 m dipping gently seaward. The lava flows diverted the Clyde River from flowing to the sea near Moruya to its present estuary at Batemans Bay. The basalt outcrop is now mostly obscured by coastal forest growth. However, a wavecut pavement of Coila Basalt can be walked over at the northern end of South Broulee Beach near Broulee Surf Club.



***Coila Basalt pavement at the northern end
of South Broulee Beach.***
Photo – Stewart Needham



*There's much more information on web sites and in books and journals.
Some of these are listed below.*

Books and publications

- ***The Geology of Australia*** – D. Johnson, Cambridge University Press, 2004
- ***Geologica: The origins of the Earth*** – Millenium House, 2007.
- ***Earth: the definitive visual guide*** – Smithsonian Institution, DK Ltd., 2004.

Web sites

- <http://www.nature.com/scitable/knowledge/library/dating-rocks-and-fossils-using-geologic-methods-107924044>
- <http://geology.com>
- <http://www.ucmp.berkeley.edu/fosrec/McKinney.html>
- <http://geomaps.wr.usgs.gov/parks/gtime/radiom.html>
- <http://geomaps.wr.usgs.gov/parks/gtime/ageofearth.html#date>
- <http://education.usgs.gov/secondary.html>