COAL PROPERTIES

The nature of coal

Coal is a combustible sedimentary rock containing both organic and mineral matter. The organic matter is derived from vegetable material accumulated under conditions which have prevented complete decay. Subsequent burial has formed a complex mixture of chemical compounds containing carbon, hydrogen and oxygen together with smaller amounts of nitrogen, sulphur and trace elements. The mineral matter consists chiefly of clay minerals, mineral forms of sulphur (mostly pyrite) and smaller amounts of other minerals. Moisture is also an important constituent.

Variations in the physical and chemical characteristics of coal result from differences in:

- the original plant material from which coal is derived
- the amount of decay that occurred before eventual burial
- the amount of contamination by inorganic material during deposition
- the temperature and pressure conditions that existed during its geological history and the coalification process.

Differences in the kinds of plant material and its biochemical alteration before burial control the type of coal. Differences in the geological conditions of temperature and, to a lesser degree, pressure during coalification control the rank of the coal. Time is not a significant factor. Increasing rank results in progressive and irreversible changes in the chemical and physical properties of the coal, in the generalised sequence of peat - lignite (brown coal) - sub-bituminous coal - bituminous coal - semi-anthracite - anthracite. The changes in rank-induced properties between these general groups is continuous but uneven. Differences in the range of impurities determine the grade of the coal. These various properties are measured by a range of analytical techniques.

Coal analysis and utilisation

Coal properties are measured by a variety of laboratory analyses. Proximate analysis gives a general characterisation of coal properties by measuring moisture, ash, volatile matter and fixed carbon. Ultimate analysis measures the chemical elements of which coal consists, and includes determinations of hydrogen, carbon, nitrogen, oxygen, total sulphur and chlorine. Other analyses measure specific energy (calorific value), ash softening temperature, forms of sulphur, mineral matter, carbon dioxide and special tests such as crucible swelling number (or free swelling index), the determination of plastic properties, grindability and screen analysis. There is also a range of coking tests which include microscopic analysis.

The results of these analyses are used to determine the suitability of a coal for particular uses. Thermal coals with a wide range of properties and quality can be used for power generation, although particular design characteristics of individual plants severely limit the coal quality variation a power station can accept. More stringent emission controls on power stations further limit the suitability of coals for generating plant. New Zealand is fortunate in having high quality thermal coals.

Steel making requires close control of coal properties, and bituminous coals with certain properties are needed to make metalurgical coke. Some coals from the West Coast of New Zealand are of exceptionally high quality, allowing them to blended with lower quality coking coals. For this reason, they can command high prices internationally and are the basis of a successful export industy. West Coast coking coals are not suitable for the Glenbrook steel mill, which uses Waikato coal in a unique direct reduction process, or for the Huntly power station.

Changes in coal properties with increasing rank

Rank[1]	Moist-ure %[2]	Volatile matter %	Fixed carbon %	Ash %	Specific energy (MJ/kg)	Physical appearance	Original depth of burial[3]
Peat	80	9	5	6	16	Soft, brown to black, poorly compacted plant debris.	
Lignite	55	20	17	8	23	Tough, dull, brown with obvious woody material.	up to 1000 m
Sub-bituminous	20	36	40	4	28	Black with faint brown tinge and dull shine.	up to 2000 m
Bituminous	2	36	60	2	35.5	Black with bright, shining lustre.	up to 5000 m
Semi-anthracite	1%	9%	87%	3%	34.5	Dark grey with metallic lustre.	up to 7500 m

1 Rank: in practice, there are further divisions within these general categories.

2 Moisture: analysis figures are typical values.

3 Original depth of burial: the depth of burial needed to change peat to a particular coal rank.

Bituminous coal from Reefton, West Coast.

Lignite from Matuara

New Zealand coal properties

There are major contrasts in properties - rank, type and grade - between the coals from different New Zealand coalfields. There can even be considerable variation of properties within a single deposit or even within one mine. This variation of properties is the result of different and sometimes complex geological histories of many New Zealand coalfields, especially on the West Coast of the South Island.

The primary control on variation of coal properties is the burial history of the original peat, which results in differences of coal rank. New Zealand coals range from very high-moisture lignite to very low-moisture bituminous coal and minor anthracite, which covers virtually the full range of coal rank. Other variations arise from the nature of the original coal-forming vegetation, the way it decomposes, and the depositional environment of the rocks within which coal seams are contained.

Detailed information on the properties of some New Zealand export coals can be found on the websites of Solid Energy NZ Ltd and the Coal Association of New Zealand.

Coal region	Age of coal	Typical seam (metres)	Coal rank (ASTM) thickness (max)	Ash content (dry basis)	Sulphur content (dry basis)
Northland	Late Eocene	2 (8.1)	sub-bituminous A	2.5-8%	1-5%
Waikato (Northern)	Late Eocene	4-10 (30)	sub-bituminous C-A	2-10%	0.2-0.3%
Waikato (Southern)	Late Eocene -Oligocene	1-5 (14)	sub-bituminous C	5-20%	0.3-8%
Taranaki	Early Miocene	1-3 (4.5)	sub-bituminous B-A	2-12%	1-4.5%
Nelson- West Coast	Late Eocene Late Cretaceous	2- 8 (24) 3-6	sub-bituminous C - semi-anthracite(18)	0.5-6% 1-5%	0.3-7% 0.3-1%
Canterbury	Late Cretaceous- Middle Eocene	1-5 (20)	sub-bituminous - s emi-anthracite	1.2-6%	0.5-2%
Otago (Eastern)	Late Cretaceous -Late Eocene	2-5 (30)	lignite - sub-bituminous B	3-8%	0.25-6%
Otago Ω	Oligocene -Early Miocene	20-60 (79)	lignite	3-20%*	0.2-0.6%*
Southland (Western)	Late Cretaceous -Late Eocene	4-14 (23)	sub-bituminous A-C	1-8%	0.3-0.6%
Southland (Eastern)	Oligocene to Miocene	2-5 (13)	lignite	3-20%*	0.2-0.6%*