En

Underground in the city

gallery texts

Please drop me in the box as you leave

Down the rabbit hole

1 We experience what is happening above ground on a daily basis, but what lies underneath the earth's surface is usually hidden from view. And because that world is largely terra incognita for us, what happens there is shrouded in mystery. Stories about tunnels used to access and rob banks or as secret escape routes capture our imagination. By their very nature, illegal resistance movements operate 'underground', shunning the spotlight. The underground scene of artistic subcultures also prefers to avoid the glare of public attention. Besides arousing our curiosity, the unknown frightens us. The devil and other monstrous creatures are said to be lurking deep under the ground. Sewage workers would be well advised to offer up a quick prayer before removing a manhole cover. On the other hand, it is to the earth that we entrust our most cherished treasures. Venture down below and a wondrous world will open up to you!

1.1 **Hepworth Manufacturing Company, *Alice in Wonderland*, 1903**

1.2 **Walt Disney Productions, *Alice in Wonderland*, 1951**

1.3 In 1877 Thomas Wallace Knox, an American journalist and author of adventure stories, wrote a weighty tome entitled *The Underground World: a mirror of life below the surface, with vivid descriptions of the hidden works of nature and art, comprising incidents and adventures beyond the light of day...* This illustration was next to the title page. It encapsulates how the underworld both fascinates us and fills us with fear. UC Berkeley Bancroft Library

The deep and mysterious underground

It is very difficult to fathom what is actually happening inside the earth and for a long time this was a matter of guesswork. Even now the deepest drilling operations into the earth's crust are mere pinpricks.
The German priest and scholar Athanasius Kircher tried to explain a number of phenomena in the influential book he wrote in 1664: *Mundus subterraneus, quo universae denique naturae divitiae*. For example, he attributed tides to the flow of water in and out of an underground ocean.

1.4 **Athanasius Kircher, *d'Onder-aardse weereld in haar Goddelijk Maaksel en wonderbare uitwerkselen aller dingen* (The underground world in its divine creation and the wondrous workings of all things, 1682)**
Most of the *Mundus subterraneus* has never been translated into English from its original Latin editions.
Ghent University Library

1.5 **Jules Verne, *Reis naar het middelpunt van de aarde (Journey to the Centre of the Earth)*, 1974 (1864)**
Two centuries after Athanasius Kircher, Jules Verne wrote his science-fiction classic *Journey to the Centre of the Earth* (1864), in which he described underground sea plains similar to Kircher's underground oceans. Today the existence of such seas is considered to be impossible. Private collection

1.6 **Mouth of the Mephisto worm (*Halicephalobus mephisto*)**
However little we know even today about what is happening in the deep layers of the earth's crust, recent discoveries prove that there are forms of life in deep layers of rock. It was long believed that single-celled organisms are the only life at great depth. But then in 2011 the Ghent professor Gaetan Borgonie found a microscopic worm 3.6 km deep in water that had been cut off from the surface of the earth for thousands of years. The animal was named the Mephisto worm *(Halicephalobus mephisto)* after Mephistopheles because, like the devil, it shuns the daylight to seek out the deepest caverns of the earth.
Ghent University, Faculty of Science, Biology Department

Bank robberies

In 2019 the underground strongroom of a branch of the BNP Paribas Fortis bank in Antwerp was broken into. It soon transpired that the thieves had reached the strongroom through the sewers and through tunnels they had dug. Another notorious and not dissimilar bank robbery was carried out by Albert Spaggiari in the French coastal city of Nice in 1976. Spaggiari and his team spent days digging a tunnel from the sewers to the underground wall of the bank vault and then a weekend drilling through the wall. They seized gold bars and jewellery worth tens of millions of euros. Later on, Spaggiari wrote an account of the raid in *Les égouts du paradis* (translated into English as *Fric-Frac: The Great Riviera Bank Robbery* (1979) and *The Sewers of Gold* (1981)). The book sold well. Spaggiari was secretly involved in making the film version in 1979.

1.7 **Extract from the VRT journal of February 5th 2019**
VRT image archive

1.8 **Albert Spaggiari, *Les égouts du paradis. Sans haine, sans violence et sans arme*, 1978** Rotor

1.9 **Excerpt from the filming of Spaggiari's *Les égouts du paradis* by José Giovanni in 1979**

1.10 **Medieval underground 'torture chambers' in Gravensteen castle in Ghent, 1875–1930**
Ghent Archives / Ghent University Library

1.11 This mask of the devil was used by the Ghent St Michael's Guild in its annual procession from the seventeenth to the nineteenth centuries. It represents the battle between Saint Michael, the guild's patron saint, and the fallen angels. This mask was worn by the person playing the part of the devil. STAM

1.12 **Coin hoard consisting of 36 coins, c. 17–18, found in Overmere in 1967** STAM

Resistance

When the world above ground is plagued by dictators, war, censorship or violence, the invisible world under the ground provides a clandestine place of refuge. Resistance publications, like *La Libre Belgique* newspaper banned by the German occupier, were printed in cellars. In novels and films, too, networks of underground tunnels, dungeons and other subterranean spaces are frequently associated with resistance and hope.

1.13 ***La Libre Belgique*, 1940**
Amsab-ISG, Ghent

1.14 **Movie clips**
Matrix Reloaded, Wachowski brothers / sisters (2003)
Metropolis, Fritz Lang (1927)
V for Vendetta, James Mc Teigue (2005)
Fantastic Mr Fox, Wes Anderson (2009)
Batman Begins, Christopher Nolan (2005)
Kanal, Andrzej Wajda (1956)

At the bottom of the ladder

The Frenchman Gustave Doré (1832–1883) is best known for his illustrations of literary masterpieces. For example, he illustrated Dante Alighieri's *Divine Comedy*, a fourteenth-century epic about an imaginary journey to heaven, purgatory and hell.
In 1872, Doré and the British journalist William Blanchard Jerrold joined forces and published a beautifully illustrated book entitled *London: A Pilgrimage*, documenting all strata of mid-Victorian London. The poorest workers are depicted working deep underground in some of the darkest and most unsavoury places in the city. These representations endorse the image of society as a pyramid, with the helpless, poorest section of the population at the bottom and the rich elite at the top.

1.15 **Gustave Doré and William Blanchard Jerrold, *London: A Pilgrimage*, 1872**
Ghent University Library

1.16 **Illustrations from:**
Dante, *Die göttliche Komödie*, 1861
Gustave Doré and William Blanchard Jerrold, *London: A Pilgrimage*, 1872
Gustave Doré, *La Ménagerie parisienne*, 1854
Ghent University Library / Bibliothèque nationale de France

1.17 ***Metropolis*, Fritz Lang, 1927**
The concept of a literally stratified society also plays an important role in Fritz Lang's 1927 film *Metropolis*. The story revolves around an imaginary city in the year 2026, in which the population is divided into 'thinkers', who live in luxury above ground, and 'workers' forced to slave away in the mines.

Sewers

A contemporary city cannot function without an efficient sewage system. And if it is to be efficient, it requires constant maintenance. Many sewage workers compare their first day working in the sewers to a descent into hell because of the difficult working conditions, the darkness, the stench, the gasses, the vermin and the permanent danger of drowning.

1.18 **Anekdoten uit de riool (stories from the sewer) documentary**
Riolenmuseum / Musée des Égouts, Brussels

1.19 **Sewage workers' boots, c.20**
Riolenmuseum / Musée des Égouts, Brussels

1.20 Marc Witpas, a worker who maintained the sewage network under Brussels for decades, once carved this sentence in the walls of the collector under Bergensesteenweg / Chaussée de Mons: "When I die, I will go to heaven, because here I lived in hell."
Riolenmuseum / Musée des Égouts, Brussels

The gates to the underground

The entrances to the underground are unusual. They are often concealed in the streetscape under a heavy manhole cover or behind a false façade.

1.21 Saint Barbara is the patron saint of those at risk of sudden death, particularly people who work underground, like sewage workers, miners, navvies and tunnel builders.
Private collection

1.22 **Manhole and cover of a drainage inspection chamber** Farys

1.23 **A false façade conceals an entrance to the underground rail network in London (Leinster Gardens)** Arvind Roy

1.24 **Replica of the foot of the bronze statue of Hermes (Mercury) by Giambologna (1529–1608) from the collection in the Louvre in Paris**
Some mythical creatures and gods are associated with the transition from above ground to below ground. In Greek mythology, the god Hermes is the conductor of souls. It is his job to accompany the shades of the deceased to the underworld. With his winged feet, Hermes is at home in both worlds. He commutes between light and darkness.
Private collection

Underground culture

The underground culture is a counterculture strongly opposed to the tastes of the public at large and to commercial profit. Those who share the beliefs of this movement are generally involved in music, the visual arts and literature.

1.25 **Raves in Brussels, Ostend, Berlin and Liège**
Julien Sigalas, Antoine Paroute, Erich Fertig en Faune

1.26 **Selection of record sleeves from the Nurse with Wound list, 1979**
Compiled by the Nurse with Wound band and listing 291 avant-garde musicians and bands. Private collection

Underground monsters

In the film world there is a rich tradition of capitalizing on our fear of creatures lurking underground, such as the living dead and sometimes mutated rats, alligators and insects. A typical example is the 1984 science fiction horror film *C.H.U.D.* or *Cannibalistic Humanoid Underground Dwellers*. The film tells the story of how New York's homeless, who live in the sewers, are infected with nuclear waste that has been dumped there. They mutate into monsters hungry for human flesh.

1.27 **Selection of monster movie posters, c.20**
Private collection

1.28 **Movie clips**
C.H.U.D, Douglas Cheek (1984)
Alligator, Lewis Teague (1980)
The Mole People, Virgil W Vogel (1956)
Tremors, Ron Underwood (1990)
Ben, Phil Karlson (1972)
Deadly Eyes, Robert Clouse (1982)
Mimic, Guillermo del Toro (1997)
Creep, Christopher Smith (2004)

Layer by layer

2 The earth has been undergoing constant change for some 4.6 billion years. Continuous weathering shapes the earth's surface. Tiny particles of material on the surface of the earth break off and are borne away by ice, wind, rivers and seas to be deposited elsewhere. Consequently, the substratum is built up of many layers. These layers or strata are named after the age in which they came into existence. The deeper you dig, the further back in time you go.
Changes in the earth's surface can also come from under the ground. The earth's crust (the hard, outer part) is constantly moving. Large pieces of crust ('plates') bend, break, collide and shift underneath each other. This is an extremely slow process, but it is accompanied by dynamic forces, which can trigger earthquakes and volcanic eruptions.
The combined action of the movements in the earth's crust and the process of disintegration and deposition means that no two places on earth have an identical substratum.

2.1 Michel Thiery (1977–1950) was a teacher in Ghent. In 1922 he founded and became the director of the Schoolmuseum, now The World of Kina. He wrote several books on physics, including *Populaire beschrijving van de grond waarop de stad Gent is gebouwd* (Popular description of the ground on which the city of Ghent is built, 1950), documenting the city's geology. Some of the fossils described in the book were collected by Thiery himself and are part of the World of Kina's collection. Rotor

2.2 This geological map shows which sediments were deposited in the Ghent region during the Tertiary period (65 to 2 million years ago). The map was produced by the Geological Institute of Ghent University in 1996.
Ghent University, Faculty of Science, Geology Department

2.3 **Lacquer profile of a trench in Moerbeke-Waas, made in 2009**
It shows the layers of a large, shallow lake from the Tardiglacial (14,500 to 11,560 years ago), around which hunter-gatherers lived in temporary settlements.
Ghent University, Faculty of Science, Geology Department

2.4 This cross-section of the underground terrain in the region around Paris was made by Georges Cuvier and Alexandre Brongniart in 1832. Cuvier is regarded as the 'founding father of paleontology', the study of fossilized animals and plants. He was the first to date layers of earth based on the fossils he found in it.
Bibliothèque nationale de France

Geology as applied science

Geology made great strides in the nineteenth century, a period when Western countries invested large sums of money in research, drilling and mapping. A good knowledge of one's own underground primarily serves the economic interest. The Belgian geologist and mining expert André Dumont is best remembered for discovering coal in Belgian Limburg. His research laid the foundations for many geological maps of Belgium and Europe.

2.5 **Geological map of Belgium, based on research by geologist Gustave Dewalque and drawn by Charles Léonard in 1903**
Royal Library of Belgium

or

Geological map of Belgium, based on research by geologist André Dumont in collaboration with Lelorrain and E. Henry and drawn by John Bartholomew in 1877
Royal Library of Belgium

2.6 **Geological map of Belgium dating from 1857, based on research by geologist André Dumont**
Bibliothèque nationale de France

The Ghent example: the Blandijnberg

The Scheldt Valley came into existence some 800,000 to 400,000 years ago. Climate change resulted in a big drop in sea level. In this dried-out area, rivers, including the Scheldt, cut deep into the landscape so that the hills rose higher and higher out of the landscape along the valleys. The Blandijnberg elevation is evidence of this slow process. The hill is the only place in Ghent where older geological layers are to be found. The rest of underground Ghent consists of sands which were deposited later.

2.7 **Drill cores from underground Ghent and Vinderhoute**
• Formed during the Quarternary (2.58 million years ago to the present day), mainly loam
• Formation of Gentbrugge (56 to 33.9 million years ago), mainly sand
• Formation of Tielt (56 to 33.9 million years ago), silt-holding sand
• Formation of Kortrijk (56 to 47.8 million years ago), heavy clay
• Formed during the Cretaceous period (135 to 65 million years ago)
• Platform, formed during the Palaeozoic (541 and 251.902 million years ago)
Royal Belgian Institute of Natural Sciences

2.8 **Samples from a drilling operation down to 74 m on the Bijloke site in 1928–29**
Royal Belgian Institute of Natural Sciences

2.9 **Two geological sectional views of Ghent: north-south and east-west**

Rotor / Jacques Verniers, Ghent University, Faculty of Science, Geology Department

Excavated finds underneath Ghent

Fossils are the remains of former plants or animals preserved in petrified form in rock. Sometimes fossils can serve to date the layer of rock in which they were found. They are evidence of former life during the geological history of the earth.

2.10 **Fossils and marine animals from under the ground in the Ghent area, collected in the nineteenth and first half of the twentieth centuries**

They were found during excavation work on the Blandijnberg when constructing the Citadel, the Leopold barracks, the Book Tower and the Feest- en Floraliënpaleis (exhibition site). They date from the Lutetian (47.8 to 41.2 million years ago) and show that in that period the region of present-day Ghent and the surrounding area lay in the sea. Several of the fossils were collected by Michel Thiery.

Snail *(Turritella edita)*
Nummulite *(Nummulites variolarius)*
Sea worm *(Ditrupa strangulata)*
Zwin mollusc *(Venericor planicosta)*
Annelida *(Rotularia nysti)*
Lutetian gastropod *(Athleta spinosa)*
Shark's teeth
Remains of skeleton of Gadiform fish
Nautilus shell with internal mould *(Nautilus cf. lamarcki)*

The World of Kina, Ghent / Ghent University, Faculty of Science, Geology Department, Paleontological Research Unit

2.11 **Bull elk (*Alces alces*) antlers, Quaternary, Weichselian glaciation (last ice age, 119,000 to 11,700 years ago)**

The antlers of a bull elk were found when constructing the car park under the Vrijdagmarkt in 1981.

Ghent University, Faculty of Science, Geology Department, Paleontological Research Unit

The changing landscape

2.12 An archaeological study (2015–16) of the ground next to the Scheldt in Waarmaarde (Avelgem) provides insight into the evolution of the landscape over a time span of more than 13,000 years. The results of the study have been translated into (among other things) a series of drawings which chart the changes in the landscape.
250,000 years ago
125,000 years ago
10,000 years ago

Ulco Glimmerveen

Natural soil

Natural soil is essential for our ecosystem. Small animals like the earthworm convert organic material into fertile soil in which plants can take root. The importance of the earthworm for soil quality was first demonstrated by Charles Darwin.
Most of the natural soil in the cities, however, is covered over and the underground is full of urban detritus. This causes problems at times of heavy rainfall because it prevents excess rainwater penetrating to the natural soil. Trees and plants therefore have difficulty finding space to take root in the urban underground.

2.13 **Charles Darwin, *The Formation of Vegetable Mould, through the Action of Worms, with Observations on their Habits*, 1881**

Hendrik Conscience Heritage Library, Antwerp / IISG, Amsterdam

2.14 **Underground root growth in plants**

GPhase, Youtube

2.15 **Stages of development in the germination of a bean, early c.20**

Ghent University Museum — Botanical Garden Collection

When the earth moves

When the earth's crust moves it causes a tremor or shock. Some tremors are gentle, others very powerful. Their force is measured with a seismometer. Some parts of the world are prone to powerful earthquakes because they are located on a fault plane between two plates. In Ghent only the very occasional earthquake is felt. The most recent powerful earthquake was in 1938.

2.16 **Judocus vander Cruycen, *Verhandelinge vande aerd-bevinghe waer-in by-ghebracht worden alle voornaemste aerd-bevinghen die er oyt in de weirelt gheschiet zijn. Doch bysonderlick de gone van den 18. septembris 1692* (Dissertation on all the major earthquakes that have taken place in the world and particularly the earthquake of September 18th 1692), 1711**

Ghent University Library

2.17 **What causes earthquakes?**

National Geographic, YouTube

2.18 **Front page of *De Standaard* newspaper of June 12th 1938**

Reporting on the damage caused by the earthquake of June 11th 1938, the most powerful earthquake in Belgium since measurements began (5.6 on the Richter scale, epicentre in Zulzeke, a former independent municipality of Kluisbergen).

Royal Library of Belgium

2.19 **Seismometer**

Royal Observatory of Belgium

2.20 The seismogram above is the registration of the Zulzeke earthquake in 1938, recorded at the monitoring centre in Strasbourg (France). The seismogram in the centre is the registration of the same earthquake, but recorded at the monitoring centre in Ukkel/Uccle (Brussels). Here the ground motion was so great that the needle that registered the recording was displaced so far that its trace can barely be seen. The seismogram below is the registration of the earthquake in Roermond in Dutch Limburg in 1992, recorded at the monitoring centre in Ukkel/Uccle (5.8 on the Richter scale).

Royal Observatory of Belgium

2.21 **Natural morphology of Belgium**

Ghent University, Faculty of Engineering and Architecture, Department of Architecture and Urban Planning

The age of humans

To study the long geological history of the earth it is divided into geological eras. They correspond to clearly distinguishable layers.
The International Commission on Stratigraphy (ICS) believes that we have entered a new geological epoch: the Antropocene. This is the unit of time during which the impact of human activity on our planet is so great that it will be visible in the earth's layers for hundreds of thousands of years. Exactly when this time period began is still a subject of discussion.
The Antropocene is not yet a formally defined geological unit within the ICS's geological timescale.

2.22 **Selection of excavated ring pulls, c.20**
Contemporary archaeology is research that focuses on the most recent past. Ring pulls tell us as much about human culture as a pot of Roman coins does.
Private collection Jobbe Wijnen

2.23 **International chronostratigraphic chart, 2018/08 version**
International Commission on Stratigraphy

2.24 **Soil pollution**
The tank at the petrol station leaks fuel into the underground. Rotor

Bearing capacity

3 If you were to build a heavy structure without some sort of underpinning, it would almost inevitably subside. A building needs foundations. Those foundations will support the weight of the building on a solid substratum. The type of foundation used depends on the stability and bearing capacity of the substratum. Amsterdam's soft, marshy ground, for instance, requires a different treatment from New York's rocky substance and from the stable limestone geology underneath Paris. Laying foundations is demanding and expensive work. In the days before the bearing capacity of the layered subsoil could be tested and calculated, the result of all the effort involved in laying foundations was uncertain. Consequently, the laying of the first stone of an important building was accompanied by lengthy rituals and offerings.

3.1 Child sacrifice in the foundations of the fortification walls of the ancient city of Megiddo, Palestine. Bronze age. Rotor

Laying of the foundation stone of st peter's abbey church

On April 14th 1629, Bishop Antoon Triest laid the foundation stone of the new church at St Peter's Abbey in Ghent. One of the rituals that accompanied such an event was the production of a commemorative medal for distribution as a souvenir. A medal was buried under the foundation stone, thereby forming a link with the underground. Traditionally one side of a commemorative medal bears a representation of the design for the building and the other side an effigy of the client or commissioning body. But Bishop Triest had Saint Peter depicted on the medal. In addition to the commemorative medals, a book of poetry was published in 1629. The poems refer to the words of Christ: "You are Peter and on this rock I will build my church." They draw a comparison with the Blandijnberg elevation in Ghent, which is said to have been provided by God as the rock on which to build the new church.

3.2 **Book of poetry dedicated to Abbot Ioachim Arsenius Schaeyck to commemorate the laying of the foundation stone, 1629**
Ghent University Library

3.3 **Medal commemorating the laying of the foundation stone, after a design by Jacques Cocx, 1629** STAM

3.4 **J. B. De Noter, *Gezicht op de Sint-Pietersabdijkerk* (View of St Peter's Abbey Church), 1820** STAM

3.5 **St Peter's Abbey in Ghent, in: Sanderus, *Flandria Illustrata*, 1641–1644** Ghent University Library

New York: geology defines the skyline

Research has revealed that there is a link between the location and height of skyscrapers in Manhattan (New York, USA) and the presence of schist layers underground. Schist is a very hard rock that provides the perfect foundations for high-rise buildings. The closer the layers of schist to the surface, the higher it is possible to build. So the tallest buildings tend to be found in Midtown, to the south of Central Park and on the far end of Manhattan, on Wall Street in the financial district.

3.6 **Fragment of schist from Manhattan**
Royal Belgian Institute of Natural Sciences

3.7 **Distribution of high-rise buildings in Manhattan and the occurrence of schist underground** Rotor

Pile village Amsterdam

As the ground under Amsterdam was originally a swamp, the soil there is very soft. Fortunately, under the peat there are also layers of sand into which piles can be sunk tens of metres deep. In the old days, wooden piles were used, but nowadays they are made of concrete. The old centre of Rotterdam was also built on poles. Songs were sung to set the rhythm while they were being driven into the ground.

3.8 **Fragment of a pile under Central Station in Amsterdam, 1870–1890**
Amsterdam Museum

3.9 **Pile drivers at work, illustrations by Jan Rinke in *Toen en nu. Van 1801 tot 1901* (Then and Now. From 1801 to 1901), 1901**
Royal Library The Hague

3.10 **Pile-driving songs**
Meertens Institute collection, Amsterdam

3.11 In 1929, J. W. Wagener painted this steam-powered pile driver in action during construction of the Bijenkorf department store in Rotterdam.
Museum Rotterdam

Outport: under-water foundations

To meet the growing demand from industry, Ghent city council took the decision to build a new outport on the Ghent-Terneuzen canal, the 'Voorhaven'. Its construction was entrusted to city engineer Emile Braun, later burgomaster of Ghent. The foundations for the quay walls were built under water with the help of caissons. These metal, bell-shaped chambers were lowered from floating structures, which were moved to build each new piece of quay wall. The masons in the caissons worked under over-pressure and so in unenviable conditions.

3.12 **Armand Heins, certificate relating to the laying of the foundation stone for the Voorhaven, June 11th 1882**
Ghent Archives

3.13 **Medal commemorating the laying of the foundation stone for the quay walls, 1882** STAM

3.14 **Quay wall and sheds at the Voorhaven, 1890** Ghent Archives

3.15 **Portrait of Emile Braun** Ghent Archives

3.16 **Plan for the development of the Voorhaven, 1886** Ghent Archives

3.17 **Building the foundations for the FNO (Filature Nouvelle Orléans) building, ca. 1899**
Buildings were constructed on marshy land in Ghent as well, including the Filature Nouvelle Orléans cotton mill at the Wondelgemse meersen (Wondelgem lakes). The foundations for the building were laid on the deeper layer of sand. Pyramidal plinths were built on top as supports for the metal, load-bearing structure of the factory building above ground.
Museum of Industry, Ghent

The Franki pile

Over a hundred years ago, the Belgian industrialist Edgard Frankignoul developed a revolutionary method to form foundation piles in the ground. This concrete foundation pile typically has an expanded foot and is known as the Franki pile. To make a Franki pile, a steel casing is filled with concrete under the ground and the concrete pressed with a heavy drop hammer that moves up and down in the casing. To this end, the firm developed drivers which set in motion the casing, the concrete and the ram. Koekelberg Basilica, Sydney Opera House and the Cathedral of Brasilia are just a few examples of buildings supported on Franki piles.

3.18 **Different stages of the Franki piling system** Atlas Fondations

3.19 **Pedagogical presentation of excavated Franki piles at the Magnel Laboratory, Ghent University, 1968**
Ghent University Museum
— University Archive Collection

3.20 **Advertisement for Franki piles**
State Archives Liège

3.21 **Load test trial** Atlas Fondations

3.22 **Foundation techniques** Rotor

3.23 **Scale model of a Franki driver**
Maison de la Métallurgie et de l'Industrie de Liège

3.24 **Concrete block from the first pile for the new branch of the Bijenkorf department store in Rotterdam in the 1950s**
It was used to carry out a load test before being polished and preserved as a memento. Museum Rotterdam

3.25 **Axonometry (perspective cross-section) of the foundations under a city by David Macaulay in *Underground*, 1976**
David Macaulay, with the consent of HMH Books & Media

3.26 **Piece of grout after testing**
Compensation grouting is used on tunnelling projects to minimize settlement (subsidence). Grout is a mixture of cement, clay and water. It is injected into the soil under high pressure, filling any identified fractures. This technique

was used, for example, during excavation work under Central Station in Antwerp (1998–2007). Beforehand, the height of the building was measured. At the first sign of any distortion while the work was under way, grout was injected into pipes which had been laid in the ground in advance.

Ghent University, Faculty of Engineering and Architecture, Civil Engineering Technology Department

3.27 In regions where the risk of earthquakes is high, designs for major buildings must first undergo a number of tests. One of these is the shake-table test, which simulates an earthquake. A prototype of the building, usually to scale, is shaken back and forth in a laboratory. This is filmed in detail so that the structure's seismic performance can be studied meticulously.

American Wood Council / Nnmason, YouTube

3.28 Failure to carry out a comprehensive study of the ground of the construction site can have disastrous consequences. The foundation piles of this twelve-storey residential building in China cracked in a landslip as a result of excavation work in the area.

engineering.com

3.29 **Presentation maquette for the Galenkop housing project (2007–2010) in Amsterdam, designed by Office Winhov**

This maquette is unusual in that it also shows the 58 piles supporting the foundations of the superstructure.

VANDERSALM-aim / Office Winhov

Burials

4 Throughout time all cultures have marked places they regard as being of special significance and attached to them a symbolic or religious meaning. The underground is one such place. Digging underground often involves ritualistic precautions to please or appease gods or mythical figures.

4.1 Caves played an important role in the spiritual lives of the first people. They performed rites in caves in a bid to establish contact with supernatural forces. Caves are the forerunners of memorial stones, temples, churches and chapels. Rotor

"We trace out all the veins of the earth, and yet, living upon it, undermined as it is beneath our feet, are astonished that it should occasionally cleave asunder or tremble: as though, forsooth, these signs could be any other than expressions of the indignation felt by our sacred parent! We penetrate into her entrails, and seek for treasures in the abodes even of the Manes, as though each spot we tread upon were not sufficiently bounteous and fertile for us!"
Pliny the Elder, *Naturalis historia*

4.2 Pliny the Elder (22–73) was a Roman soldier, magistrate and writer. Only one work by him has survived: *Naturalis historia*. It deals with the universe, geography, cultural anthropology, zoology, botany, mineralogy and medicines of plant and animal origin. Pliny was a moralist: he criticized excessive luxury and also people's lack of respect for the earth.

"For the first time in millennia, most of us don't know where we will be buried, assuming we will be buried at all. The likelihood that it will be among our progenitors becomes increasingly remote. From a historical or sociological point of view this is astounding. Uncertainty as to one's posthumous abode would have been unthinkable to the vast majority of people a few generations ago."
Quote from Robert Pogue Harrison's book *The Dominion of the Dead*, 2003

Vulferus

4.3 From the early Middle Ages, the dead were buried in consecrated ground. Graveyards were sited close to churches and were part of everyday life. Several graves were found during excavation work on Sint-Pietersplein in Ghent in 2002–06. One of the excavated skeletons has been identified as Vulferus. Under the head of the deceased is a stone bearing this text: "Hier rust Vulferus, een leek, die op de 4de Iden van februari 1013 [10 februari 1013] overleed." — Here lies Vulferus, a layman, who died on February 10th 1013. The text on the bottom of the stone is particularly interesting: "Als je me ook ziet, dan smeek ik je om me te laten rusten." — If you ever see me, I beg you to let me rest in peace.

Built Heritage and Urban Archaeology Department Ghent

Last judgement in Christianity

In the Christian tradition, the deceased are buried in consecrated ground, where they find their last resting place in anticipation of the Last Judgement. The Day of Judgement is when the dead will rise from their graves and be judged by God along with the living. Some will be cast into hell, others will be allowed to enter the kingdom of heaven.

4.4 **Hartmann Schedel, *Liber Chronicarum*, 1493**
Ghent University Library

4.5 **Stained glass depicting the resurrection of the dead on the Day of Judgement, c.20 copy of a c.16 original** STAM

Burials

As a result of population growth, by the eighteenth century cemeteries in city centres were becoming overcrowded. Furthermore, for reasons of hygiene, burial outside the city was regarded as preferable.

4.6 **Cemeteries in Ghent city centre, c.18**
Rotor / Royal Library of Belgium

4.7 Work to clear churchyards in Paris began in 1786. The human remains were transferred to the derelict tunnels built to consolidate the limestone quarries, better known as the Catacombs. Photographs by Félix Nadar, 1861
Bibliothèque nationale de France

4.8 In Bolivia miners make sacrifices to a devil god, El Tio (The Uncle). They try to appease him in the hope that he will protect them during their dangerous work underground.
Fotosearch

4.9 This photograph was taken by W. H. Kretchmar at a remote place in the Australian outback in 1910. It shows Aboriginals leaving a cave from which they have fetched yellow ochre. They are walking backwards and carefully wiping out their footprints to prevent the malevolent spirits of the cave, the Mondongs, harassing them. Both the mining of red ochre and its use always went hand in hand with important rituals, which can be interpreted as an attempt to appease the forces of nature and avoid offending them.
Western Australian Museum

4.10 Red ochre is a natural pigment which has been used for cave paintings since prehistory. The powder is a mixture of silicon and clay. It owes its rust colour to the iron oxides it contains.
Royal Belgian Institute of Natural Sciences

Japanese rituals

In Japanese mythology, a large catfish by the name of Namazu lives in the mud under the islands of Japan. When he manages to move, he causes earthquakes. This makes the underworld angry and the upper world has to pay the price. However, his hiding place is guarded by the god Kashima.

4.11 **Illustrations of Namazu, c.19**

From the collection belonging to the International Research Center for Japanese Studies (Nichibunken), Kyoto

4.12 Jichinsai is a modern-day ritual performed by a priest before the start of a building project to pacify Namazu. Both the client and the contractor must attend this ground-breaking ceremony.

Philippe Bonnin

4.13 **A pacifying cornerstone in Kyoto**

Philippe Bonnin

Building blocks

5 Ground and landscape have greatly influenced what has been built in cities. Sometimes the raw materials can be excavated locally if the soil is rich in natural stone, or in sand and clay to make bricks. Otherwise, building materials may have to be brought in from a wider area by river or road. In today's globalized world, building materials for our cities are imported from all over the world. As this has an adverse effect on the environment, ways of producing building materials extracted from the ground locally or from waste materials are being explored.

Building blocks from under the ground

Natural stone is stone that is found in nature and suitable for use as a building material. The surface of the stone is often tooled after mining to make it smoother or perhaps rougher. The choice of finish depends on the type of stone and the use it is to be put to. Bricks are man-made stones baked from clay to which sand or ores may be added.

5.1 **Selection of natural stones**

Ghent University, Faculty of Science, Department of Geology and Soil Science

5.2 **Building with natural stone and building with bricks** Rotor

5.3 **Selection of bricks**

Built Heritage and Urban Archaeology Department Ghent / Rotor

5.4 **Building materials dug up in Belgium** Rotor

Natural stone in Ghent

The use of natural stone as a building material has varied in the course of time, depending on its availability and cost. The material is transported by water or road to Ghent from quarries elsewhere.

5.5 **Selection of fragments of natural stone from buildings in Ghent**

Built Heritage and Urban Archaeology Department Ghent

Urban mining

BC architects & studies and BC materials are a Brussels-based architects' collective that experiments with reusing left-over materials from building sites.

With thanks to BC materials

5.6 **Three building sites in Brussels from where BC materials has taken left-over materials**
Left: demolition of office tower (concrete rubble)
Middle: building excavation, pure Bruxellian sand
Right: building excavation, Yperian clay

5.7 **Samples of concrete rubble, Bruxellian sand and Yperian clay**

5.8 **Three products marketed by BC materials**
Left: *Kastar.* Mixture of earth and concrete rubble, sold in bulk. Kastar is used for interior walls and floors made of rammed earth.
Middle: *Brickette*. A modular building block obtained by compressing loam with some sand. Used in load-bearing and non-load-bearing interior masonry work.
Right: *Brusseleir*. A ready-to-use loam plaster sold in bulk for plastering interior walls.

5.9 **Application of three building materials: Kastar in Negenoord, Dilsen-Stokkem; Brickette in Fort V, Edegem; Brusseleir in Bokrijk**

Paris

Paris is built on top of a thick layer of lime. Up until the eighteenth century, the local limestone quarries supplied almost all the stone to build Paris. Gypsum is also extracted from underground mines. Gypsum is the main ingredient for making plaster.

5.10 **Section of the Seine Valley by Stanislas Meunier, 1875**
Bibliothèque nationale de France

5.11 **Location of the quarries underneath Paris, from: Eugène de Fourcy, *Atlas souterrain de la ville de Paris*, 1855**
Bibliothèque historique de la Ville de Paris

Underground mining is not without its risks: sooner or later the quarries collapse. One of the most catastrophic incidents occurred in 1961 near Clamart, to the south-west of Paris. Six streets caved in, destroying 27 buildings and killing 20 people. Gradually the limestone quarries were abandoned and a total ban on mining followed in the whole department of Seine in 1962.

5.12 **Excerpt from *Journal Les Actualités françaises* of June 7th 1961**
Institut national de l'audiovisuel

5.13 **Plaster of Paris**

These simple scientific displays show how granular materials like sand and clay behave when they are piled up. The French organization Amàco runs courses on rammed earth, a natural building material, and the displays are part of their *Grains de bâtisseurs* workshops. Amàco

5.14 **Photoelastic effect in granular materials**
Plastic disks are placed under polarized light to see how they change form under pressure. When vertical pressure is exerted on the granules of the plastic, this force becomes visible in the form of illuminated coloured lines. The forces spread in the material via these illuminated fringes, creating a tendency for them to branch off sideways.
To build with rammed earth, the layers are tamped down into a form, which has to be very sturdy to absorb the sideward forces. The colour intensity depends on the degree of compression. The grains at the bottom are pressed far less than those on top. So rammed earth must be applied in successive thin layers because if the layer is too thick, the compression pressure doesn't reach the bottom of the layer.

5.15 **Concrete mixer**
Two types of sand of different grain size are mixed together. When they are tipped out and form a heap, the grains divide according to size: the smallest remain in the middle, the largest roll to the sides and form the branches of a 'sand tree'. As the system is further disordered by setting the sand or powder in motion, the grains rearrange themselves and group together according to size or shape. This phenomenon is called granular segregation. To prevent the grains regrouping, water has to be added during mixing so that the grains stick together and don't separate. The blades of the concrete mixer also help make the mixture more homogenous.

5.16 **1+1 = 2?**
This transparent frame is filled partly with coarse gravel and partly with fine sand. This cross-section shows how the fine sand finds its way between the coarse particles and gradually fills up all the openings. This explains why a mixture of grains is more compact than separate grains. So in a granular material 1 + 1 does not make 2.
By studying how the grains accumulate, it is possible to show how the atoms arrange themselves in the material.
A void will always be a weak zone.
So it is interesting to see which accumulation fills the most space, to obtain as compact a material as possible.
Compactness is crucial for the solidity of granular materials like earth and concrete.

Nuclear waste storage in Belgium

Deep beneath the ground in Mol, research has been carried out since the 1970s into the possibility of storing high-level radioactive waste from Belgium's nuclear power stations in the 30-million-year-old layers of clay. One of these layers appears as an outcrop in Boom, but is found deep underground in the Kempen/Campine region. The name of the underground research laboratory in Mol is HADES (High Activity Disposal Experimental Site).
A decision as to whether or not to choose this form of storage has not yet been made. In the meantime, the nuclear waste is being stored in purpose-built repositories above ground.

5.17 **Boom clay from the HADES underground laboratory in Mol**
When excavated at the depth of 225 m, this clay is of high plasticity. Exposure to the air makes it dry and hard. ESV EURIDICE GIE, Mol

5.18 **Temporary storage of barrels of high-level radioactive waste in a repository above ground** NIRAS

5.19 **Article from *De Standaard* newspaper of August 23rd 2018 about the escalating costs of storing nuclear waste in deep clay**

Surplus earth: the Damsloot lake incident

The Stabroek-based contracting firm Aertssen's disclosure in January 2019 that it wanted to dump large quantities of earth in the deep Damslootmeer (Damsloot lake) near Ghent raised a furore. The company was looking to dump a total of 750,000 m^3 (or some 1.2 million tons) of earth excavated elsewhere over a period of fifteen years. The application was met with a negative response from the executive of the Province of East Flanders. The incident shows that contractors have run out of ways of disposing of surplus earth. Interestingly, Damslootmeer is itself the result of a building site: it is an artificial expanse of water that was created by extracting sand to construct the E17 motorway in the early 1960s.

5.20 **Article from *De Standaard* of January 20th 2019 about filling up Damslootmeer**

5.21 **Map of the area around Damslootmeer and the E17**
Rotor

5.22 ***Het Nieuwsblad* weekend supplement of June 8th 2019 about the vast quantities of surplus earth in Flanders**

5.23 **Section model of the underground and the built environment of Paris, 1937**
Mission Patrimoine professionnel de la Ville de Paris

Diggers

6 Moles with their sharp claws and strong muscles and earthworms with their robust digestive system are built for digging underground. Human beings, on the other hand, require the help of implements to dig, move excavated earth and reinforce tunnels to prevent them collapsing. For a long time, man's most important implements to carry out those tasks were the spade, pickaxe and barrow. Since the Industrial Revolution, more powerful excavators have been required to quarry fossil fuels (coal, petroleum and natural gas) on a large scale. The evolution of those machines is such that it is now possible to excavate huge quantities of soil, build long tunnels and drill through rock in next to no time.

Eccentric diggers

The underground has its own gallery of honour: people, animals and machines whose strength is digging.

6.1 **William Cavendish-Scott-Bentinck, 1800–1879**

William Cavendish-Scott-Bentinck, 5th Duke of Portland, was something of a maverick. Under the family's landed estate of Welbeck Abbey, he constructed subterranean rooms, which he linked by kilometres of passageways. They include a ballroom fitted with a hydraulic lift, which can carry up to twenty people. This excavation work was extremely expensive and carried out by hundreds of workers.

6.2 **Naked mole-rat**

The naked mole-rat is a quirky rodent which, like bees and ants, lives in a colony. It uses its specially developed jaw and teeth to dig underground tunnels. The naked mole-rat has very poor sight but sensitive hearing and a keen sense of smell which it uses to check its direction and find its way through the complex maze of tunnels. As the temperature in the tunnels is stable, the naked mole-rat doesn't need to produce extra warmth to regulate its temperature and therefore requires less sustenance. Over time the naked mole-rat's body has adapted to life underground. It produces a substance that makes its skin elastic and thick, so that it doesn't injure itself when digging.

6.3 **Georgius Agricola, 1494–1555**

Georgius Agricola was a German scholar and scientist, who is also referred to as the father of mineralogy. In 1556 Agricola wrote his most famous work, *De re metallica (On the Nature of Metals)*. In this book he wrote about mining and the different sorts of iron ores which are to be found deep underground. He also explained how these ores are located and then melted down into various metals, such

as silver and gold. This information reached a wider public thanks to Agricola's work.

6.4 **Cappadocians**
The diggers of Cappadocia lived in underground towns in this region in central Turkey. The area is known for its soft volcanic tuff, formed from deep deposits of volcanic ash. The tuff is the dream stone of any excavator: it is soft and pliable but also very strong and retains its shape. Nobody knows exactly how many subterranean towns there are in Cappadocia.

6.5 **Invasive ant**
Living under Citadelpark in Ghent, among other places, is a gigantic colony of ants that has reached pest status. This exotic ant travelled here in compost imported by the Ghent Floralies flower show in the 1970s. The *Lasius neglectus* now feels very much at home here and is gradually extending its colony. It lives entirely underground and — unlike the common black ant — the queens don't fly off to build new nests elsewhere. Consequently, supercolonies are formed, consisting of a network of nests, and enabling the ants to displace a lot of soil locally. The colony under Citadelpark already covers some 19 hectares.

6.6 **Earthworm**
Earthworms are burrowing animals. As they dig, they mix up the layers of soil and as they move through the ground, they eat up the soil. After extracting the useful nutrients, they leave the soil behind. This digested waste, known as castings, 70% of which consists of humus, is very nutritious for plants. In this way, earthworms contribute to a healthy and fertile soil. Even the Greek philosopher Aristotle recognized the important role they play: he called earthworms "the intestines of the earth". Depending on the soil, the climate and the types of worm, it is estimated that over a period of fifty years pretty well all soil in a garden or field passes through earthworms' digestive tracts.

6.7 **Marc Isambard Brunel (1769–1849) and Isambard Kingdom Brunel (1806–1859)**
Without Marc Isambard Brunel, tunnel building would probably have looked very different. In 1818 this British engineer of French origin came up with an ingenious invention: the tunnelling shield. As the miners cut away the earth in front of them, this gigantic iron shield was forced forward by powerful screw jacks. Work on a tunnel under the Thames in London started in 1825 using this ingenious technique. This, the first ever tunnel under a river, is an impressive 396 metres long. Marc Isambard's son, the engineer Isambard Kingdom Brunel, supervised the work. The tunnel was completed in 1843.

6.8 **Shipworm**
Marc Isambard Brunel can take the credit for constructing the tunnel under the Thames in London. His tunnelling shield was inspired by the shipworm. Despite its name, the shipworm is not a worm, but a mollusc. It has mini-shell valves at the front which enable it to rasp its way through wood, secreting lime to provide the walls of the tunnels it digs with a solid lining and prevent their collapse. Because shipworms damage the wood of ships and posts under water, they are also referred to as 'termites of the sea'.

6.9 **William Lyttle, 1931–2010**
The retired William Lyttle had a very odd hobby: he spent forty years digging an extensive tunnel complex under his house in London. He was bitten by the bug when he dug a wine cellar single-handedly in the early 1960s. After the wine cellar came a tunnel, and another tunnel, and another … There was no stopping him. He continued digging and hollowing out, until his front doorstep collapsed in 2006 and he had to bring his excavation work to an end. His tunnel network was 9 metres deep and spread up to 20 meters in every direction. William Lyttle earned himself the nickname of the Mole Man.

6.10 **Bertha, °2013**
Bertha saw the light of day in Seattle (Washington, USA) on June 30th 2013 and weighs a whopping 6,100 tons. She is 17.5 metres in diameter and 99 meters long. Little wonder the inhabitants of Seattle call her 'Big Bertha'! In 2013 Bertha was the largest tunnel boring machine in the world. On July 30th 2013 she began drilling the 3-kilometre, double-decker tunnel SR99 under downtown Seattle. After some headwind and several miscalculations, she completed the tunnel in 2017. Thanks to Big Bertha, 500,000 vehicles now drive through the tunnel every week.

6.11 **Lystrosaurus**
The Lystrosaurus is a prehistoric herbivorous animal. Its heavily built forelimbs suggest that it was a powerful digger. It was roughly the size of a dog and resembles a cross between a lizard and a pig.
The Lystrosaurus is one of few species to survive the Permian-Triassic mass extinction event, some 250 million years ago. It is thought to have owed its survival to its burrowing habit, which was highly advantageous in a world where the atmosphere was obscured by dust and ash for centuries.

6.12 **Terranef**
The Terranef is a fictitious excavating machine from the Belgian comics series *Suske en Wiske (*Spike and Suzy). It was invented by Professor Barabas and first appears in the *Highland Games* album (*De Knokkersburcht*, 1954). Mounted on the front of the Terranef is a diamond disk powered by an atom engine, which causes it to rotate at high speed and melt all the materials in its path. The Terranef drills its way through the molten layers. A cooling system on the back re-freezes the molten materials.

6.13 **Old educational poster about the earthworm, ca. 1930**
Private collection

Digging like an earthworm

Earthworms are indispensable tunnel builders. Their digging, ploughing and composting activities make for a fertile subsoil and the burrows they create act as ducts that oxygen can pass through. The earthworm finds nutrition as it literally eats its way through the soil. Anything it cannot derive nutrients from, it excretes from its body.
Digging tunnels with the aid of a tunnelling shield is similar. In the old days, the earth was dug out manually and taken away by cart. Nowadays this is done automatically using a tunnel boring machine: the cutter

head at the front rotates and digs the earth away. The excavated material is mixed with a liquid and piped up to ground level.

6.14 **Earth drill** MOT, Grimbergen

Digging like a mole

Moles have very small hind paws, but large forepaws and strong shoulders, well suited to digging. They have six fingers on each forepaw and an extra 'thumb', which they use to rest on while digging. The thumb also enlarges the paw, thus enabling the mole to scoop away more sand in one go.
A hoe, spade or excavator works according to the same principle: trenches or pits can be dug with a shovel on a long arm. The excavated earth is taken away in wheelbarrows, carts or skips.

6.15 **Hoe** MOT, Grimbergen

6.16 **Shovel** MOT, Grimbergen

6.17 **Excavation worker's trenching shovel** MOT, Grimbergen

6.18 **A drainage worker's 'pipe spoon'** MOT, Grimbergen

6.19 **Wheelbarrow**
Lochristi Ornamental Plant Cultivation Museum

6.20 **Timber formwork for a tunnel, from: Georgius Agricola, *De re metallica*, 1556**
Ghent University Library

6.21 **Cart, from: Georgius Agricola, *De re metallica*, 1556**
Ghent University Library

6.22 **Alphonse de Neuville, a horse being lowered into a mine shaft, 1867**
Shutterstock

6.23 **John F. Mailer, a horse pulling a coal train in the mines in New Aberdeen (Canada), 1946** Library and Archives Canada

6.24 **Drawings from the Thames Tunnel Archive illustrating the construction of the tunnel, 1825–1843**
The Brunel Museum, London

6.25 **Excavating the Ghent-Terneuzen canal with a steam-powered excavating machine, 1874–1878**
Ghent University Library

6.26 **Drill bits**
Museum of Industry / Royal Belgian Institute of Natural Sciences

6.27 **Model of a loader**
The diesel engine behind the operator drives the rubber wheels and the hydraulic engine. In its turn, the hydraulic engine drives the movements of the loader bucket.
Rotor

6.28 **Model of an excavator with caterpillar tracks powered by diesel**

6.29 **Model of a tipper lorry powered by diesel**

6.30 **Skeleton of a mole *(Talpa europaea)***
GUM, collection Zoology Museum

Ground freezing

In exceptional cases the underground is temporarily frozen in a bid to stabilize the soil and prevent water leaching away. Coolants are pumped into the ground via a network of pipes. When the surrounding ground is frozen, the innermost core can be dug out without danger of collapse. Once the building activities have been completed, the ground can be thawed. This technique was used, for example, in mining and when digging the ventilation shafts for the Brunkeberg Tunnel in Stockholm in 1886. The ground freezing technique is still regularly used today, including for the recent construction of the North-South underground rail link in Amsterdam.

6.31 **Film clip about ground freezing** MIVB

6.32 **Article about excavation work for the Brunkeberg Tunnel in *La Nature*, 1886** Rotor

The tentacled city

7 A network of pipes and cables — an estimated 500,000 km in Flanders — runs underground, supplying cities with gas, water, electricity, sewerage and telecommunications twenty-four seven. Laid underground, they are better protected against weather, deterioration and damage. Laying cables and pipes underground is a fairly recent phenomenon. Until the nineteenth century, surface water was used for drinking water in many towns and cities. Fuel (wood, turf, etc.) was transported overground by road and river. As surface water became increasingly polluted, from the mid-nineteenth century city councils were compelled to supply drinking water from outside the city through an underground network of pipes. This was facilitated by industrially-produced pipes made of cast iron and later on steel. The gradual underground distribution of gas, electricity, sewerage and telecommunications followed.
Since the 1990s the underground cable network has been extended apace in the wake of the rapid development of the telecommunication market and its liberalization. However, the antiquated pipes and cables were not removed, with the result that space underground is in short supply, making it increasingly difficult to install new pipes and cables.

The first pipes for transporting water

The very first closed pipes for transporting drinking water were made of hollowed-out tree trunks. Terracotta and lead pipes followed. Both were in general use in Roman times. The advantage of lead water pipes was that pieces of pipe could easily be welded together. However, the softness of lead made it impossible to convey water through pipes under very high pressure. Another disadvantage, which only came to light in the twentieth century, is that lead is poisonous.

7.1 **Fragment of a wooden water pipe from Ronse, c.19** Farys

7.2 **Fragment of a lead water pipe, Roman period**
Maison de la Métallurgie et de l'Industrie de Liège

7.3 **Fragment of a lead water connection, 1881** Farys

7.4 **Terracotta pipe**
Maison de la Métallurgie et de l'Industrie de Liège

Advent of cast iron and steel

Much of the credit for the success of the cast-iron pipe for transporting water must go to Rennequin Sualem (1645–1708), a carpenter from the principality of Liège. He invented a method for pumping river water to fountains at a much higher location using a hydraulic machine. Employing this same principle, he also built a machine to supply water to the ponds and fountains at the Palace of Versailles in France. The pipes that brought up the water under pressure were made of cast iron. The region around Liège, which for centuries had been famous for its iron ore, became an important centre for the production of iron ores and later steel water pipes. From the nineteenth century, steel was increasingly used for manufacturing water pumps and fountains too.

7.5 **Cast-iron segment of the water pipes at Versailles, c.17**
Maison de la Métallurgie et de l'Industrie de Liège

7.6 **Piece of iron ore**
Royal Belgian Institute of Natural Sciences

7.7 **Old pump providing drinking water, c.19** Farys

7.8 **Engraving of water management in Paris from *La Nature. Revue des sciences et de leurs applications aux arts et à l'industrie*, July 10th 1886**
This engraving shows the water supply system in Paris in the 1880s. Water was conveyed through heavy cast-iron pipes. The pipes were placed in the sewer under the street, making them easily accessible underground for maintenance and repair. Typically of the Parisian system, the water supply is split. The pipeline on the left transports non-potable water from rivers or canals. This is intended for use by industry and the fire service and for public sanitation. The pipeline on the right carries spring water, which is sometimes harvested far outside Paris and intended for private use and for supplying fountains in the city with potable water.

Compagnie Générale des Conduites d'Eau

In 1865 the industrial heritage resulting from Rennequin Sualem's work gave rise to the Compagnie Générale des Conduites d'Eau in Liège. The company developed water supply systems which were used all over the world. Initially the pipes were made of cast iron, later on steel.

7.9 **Trade catalogue, Compagnie Générale des Conduites d'Eau, 1889**
MOT, Grimbergen

7.10 **The Compagnie Générale des Conduites d'Eau's pavilion at the World Fair in Brussels, 1910**
La Fonderie, Sint-Jans-Molenbeek / Molenbeek-Saint-Jean

Drinking water supply Ghent

Initially attempts were made to supply towns and cities with potable water by installing public pumps. As the population began to soar in the second half of the nineteenth century, so too did the need for a public water supply network. After initiatives by both private individuals and city councils, in 1891 a partnership between several Belgian towns led to the establishment of the Compagnie Intercommunale des Eaux, the first intermunicipal water company and forerunner of today's Farys. From 1905 Ghent was supplied with water from "den Bocq", an area of natural springs in the Condroz region.

7.11 **Water meters, 1935–2019** Farys

7.12 **Didactic presentation of the connection of a dwelling to the drinking water network**
It was used for training technical staff at TMVW (now Farys).
Farys

7.13 **Old coupling of two cast-iron pipes, excavated in Hoogstraat / Rue Haute in Brussels in the spring of 2019**
In the nineteenth century pipes were laid for the distribution of coal gas, which was used for street lighting, but also in the home for heating and to cook on as well as for lighting. Brussels was the first city on the European continent to have a coal gas network. Once obsolescent, the disused pipes remained under the ground. Only when they are in the way of the installation of new pipes are pieces broken off and removed. Rotor

Gas in Ghent

From 1824 to 1881 city architect Louis Roelandt ran a gas factory in the Waalse Krook area of Ghent: Imperial Continental Gas Association. Pit coal degasification released a gas that was suitable for the production of power such as lighting. Among other things, Roelandt supplied gas for lighting the Town Hall, the university buildings in Voldersstraat and the theatre on the Kouter.
To meet the growing demand for coal gas, in 1889 the city founded the Gasmaatschappij van Gent / Compagnie du gaz de Gand on what is today Gasmeterlaan. This factory's two surviving gas tanks are a familiar sight for many a Ghent citizen. The gas tanks have a capacity of 10,000 m^3. In 1960 the city switched to natural gas. These days heat networks and heat pumps are installed as an alternative to fossil fuels. This is how STAM is heated, for example.

7.14 **Cast-iron street light fuelled by gas, ca. 1900** Museum of Industry, Ghent

7.15 **Gas Works, Imperial Continental Gas Association** Ghent Archives

7.16 **Gas tanks belonging to the Gasmaatschappij van Gent / Compagnie du gaz de Gand on Gasmeterlaan, 1943**
Ghent Archives

7.17 **Business card, J. De Sutter en Co., gas manufacturer, 1843–1880**
House of Alijn, Ghent

7.18 **B. Neyt, *La fabrique de gaz de Roelandt à Gand*, 1833**
Museum of Industry, Ghent

Electrical conductors

Built in 1885, Brussels' electricity generating station was the first initiative in Belgium to generate and distribute electricity. Because of lobbying on the part of the gas company however, it was the twentieth century before the electricity network was extended. Most of the cables at that time were made of copper, which was imported from mines in the Congo, a Belgian colony. Today copper is so expensive that faulty underground high-voltage cables are replaced by aluminium cables rather than copper.

7.19 **Faulty, high-voltage copper cable from Hoogstraat in Brussels, 1930s**
Each of the three conductors is insulated with paper soaked in oil. This cable carried current under a pressure of 10,000 volts. Rotor

7.20 **New, aluminium high-voltage cable, 2019** Rotor

7.21 **Piece of malachite**
Malachite is a mineral from which copper can be extracted. The largest reserve of malachite in the world is in Central Africa, including in the Congolese province of Katanga.
Royal Belgian Institute of Natural Sciences

7.22 **Types of electric cables produced by Ateliers de Constructions Électriques de Charleroi**
Maison de la Métallurgie et de l'Industrie de Liège

Ghent live

After a short period in which the Brussels-based A.E.G. — Union électrique supplied Ghent with electricity, Ghent city council wanted to see electricity under state control. So in 1911 the Centrales Électriques des Flandres was founded. In 1913 the company had a power station built in Langerbrugge along the Ghent-Terneuzen canal. Gradually the site was extended. After a merger, the power station came into the ownership of EBES, the later ENGIE Electrabel. The power station is no longer in use. To meet the growing demand for electricity, additional power stations were built in the Ghent area, including the municipal electric power plant on the Ham in 1924.

7.23 Badly damaged by German bombs in November 1918, the power station in Langerbrugge came back on stream in December 1919.
Ghent Archives

7.24 **Switchboard for an electrical installation produced by Declercq Frères Entreprises Électriques in Brussels** Museum of Industry, Ghent

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Telecommunications

From the beginning of the nineteenth century, experiments were carried out into communication by means of electrical pulses: telegraphy via (underground) electric cables. A global code system was developed for these signals, better known as the Morse code. After the success of the telegraph, the invention of telephony was the next big step in the transmission of voice via cables. The most advanced data

cables today are fibre optic cables which use light to transmit information. Most internet traffic passes through undersea cables linking the continents. The number of such cables continues to increase. A modern-day undersea internet cable is only a few centimetres thick. The active part of it is much thinner and consists of a couple of very fine fibres of glass, each the thickness of a hair. The rest of the cable consists of layers of plastic, steel, copper and cotton soaked in tar, which serve as cladding and protection for the glass fibres. This type of cable can transmit 100 terabytes of internet traffic per second (1 TB = 1024 GB).

7.25 **Film clip about undersea cables**
Vox, YouTube

7.26 **Modern-day submarine communications cable**
Sibelga

7.27 **State-of-the-art data cables, 2019**
Rotor

7.28 **Representation of the evolution of a European city above and below ground, 1780–1890-2019**

1780
Until the nineteenth century there were practically no pipes underground, only cellars and rainwater cisterns. On the street we see a man selling drinking water, a rag-and-bone man and a manure collector. A man is sweeping up horse manure, which he will sell to a farmer.

1890
There is a sewer under the street, to which most of the terraced houses in the street are connected. Underground we also see the main supply pipe for drinking water. Branches lead to the houses of the well-to-do. Poorer families went and fetched their water from the public pump, which underground pipes supplied with water. Cast-iron pipes running under the street pipe coal gas under high pressure to the ornamental street lamps. Most of the houses have a gas connection, which is used to light the rooms. Sometimes a stove is also connected to it.

2019
New pipes for gas and water in lighter metals or plastic run under the street, while the old cast-iron pipes still underground slowly rust away. The sewer is unchanged but showing signs of wear. The masonry is clearly in need of repair. Electricity and data cables run under the pavement. A few houses have a rainwater cistern again. New-build blocks of flats spring up here and there with garaging deep underground. Several months were spent pumping out groundwater to create the garaging, which didn't do an old tree any good.

Rotor

A disaster in Gellingen

On July 30th 2004 a gas explosion in Gellingen cost 24 people their lives. The explosion resulted from damage to the gas line during excavation work several weeks earlier.

To reduce the number of accidents during excavation work, the Flemish Ministry of Public Works developed KLIP, a cable and pipes information portal. Today architects, contractors and consultancy firms looking to carry out groundwork can contact KLIP for information about the location of pipes.

7.29 **Gas disaster in Gellingen, July 30th 2004**
Belga Image

7.30 **Promotional film for KLIP, the cable and pipes information portal.**
Flemish Government

7.31 **Bicycle with hand pedals, used by TMVW (now Farys) to inspect the main drinking water supply pipes, ca. 1940** Farys

Sewers

8 Until the early nineteenth century, waste in most towns and cities was discharged into rivers, canals and gullies. Urban populations grew rapidly as a result of industrialization, causing further pollution of watercourses. This, combined with poor hygiene, led to outbreaks of disease.
Large cities like London, Paris and Brussels resorted to covering over watercourses and installing closed system sewers. Human excrement, once a valuable fertilizer, was carried away as quickly as possible by waste water. The above-ground city was separated from its underground discharge pipes.
In Ghent covering over and filling in watercourses and canals went hand in hand with the redevelopment of various parts of the city. A drawback to the extensive sewage network is that most of the rainwater drains away into the sewers, causing the substratum to gradually dry out.
In the second half of the twentieth century, Ghent's industries moved to the port area and new sewers and water treatment systems were laid. This led to an improvement in the quality of the watercourses. Today many watercourses in the city centre are being opened up again.

8.1 **Flooding in Ghent, 1870–1871: Old St Elisabeth Beguinage**
Ghent Archives

Sewage farms

In several large cities right into the nineteenth century carts would collect human excrement in barrels or buckets and take it outside the city to be used to fertilize agricultural land. Once the first sewers were laid in the nineteenth century, the stream of faeces was channelled to sewage farms, usually located on low-lying grassland, which was irrigated with water containing faeces. Most of those farms were run by the government. At one time, Berlin had ten sewage farms. The advantage was that both the sewage water and the faeces were put to good use. Sewage farms fell into disuse as a result of population growth in the cities at the end of the nineteenth century, for the farms could no longer cope with the ever-increasing quantities of faeces. After that, the sewage water was usually discharged straight into the watercourses.

8.2 **Sewage farm near Barking (UK)**
Wellcome Library, London

8.3 Before underground pipes were laid, potable water was distributed by a water seller. The manure collector, the rag-and-bone man and the scavenger were responsible for collecting human excrement and other refuse.
Alamy / STAM / The J. Paul Getty Museum / Université libre de Bruxelles

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In the nineteenth century, the low-lying areas in the centre of Ghent flooded almost annually. Moreover, there were regular outbreaks of cholera. The city council responded by filling in or arching over the watercourses and quickly built an extensive sewage system.

8.4 **Map showing Ghent's old waterways**
Ghent University Library

8.5 **Flooding in Ghent, 1870–1871: Tichelrei, Lower Scheldt**
Ghent Archives

8.6 **Saint Roch (Rocco) medal for protection against cholera**
STAM

8.7 **Pedagogical maquettes of different types of sewers, pre-1889**
Musée des arts et métiers, Paris

8.8 **Bust of Napoleon-Liévin de Pauw**
Napoleon-Liévin de Pauw (1800–1859) studied law, but also took a great interest in infrastructure work. In 1842 he became both professor of law at the University of Ghent and alderman of public works for the city. In 1850 he was the first zealous advocate of building an extensive sewage system in Ghent. What made his proposal original is that the type of sewer only carried rainwater and household water. The system was self-cleaning, stench-free and required little maintenance. The discharge of faeces into the sewer would be controllable and strictly forbidden so as to avoid the sewers becoming contaminated and a precious fertilizer going to waste. The city council considered De Pauw's detailed proposal much too expensive and rejected it. STAM

8.9 From 1853 sanitation work in Paris was carried out on a large scale. The sewage system, parts of which dated from the Middle Ages, was also overhauled. Once the work was completed in 1865, the photographer Félix Nadar was asked to photograph the underground sewage infrastructure.
Bibliothèque nationale de France

8.10 **Engraving showing cross-sections of Brussels' nineteenth-century sewage system**
The image top right shows a section under Anspachlaan / Boulevard Anspach, where the sewage pipes run next to the recently over-arched Zenne/Senne river.
Riolenmuseum / Musée des Égouts, Brussels

8.11 **Educational poster relating to water management, ca. 1960**
Rotor

8.12 **Filling in or arching over Ghent's waterways down the years**
Ghent Archives

8.13 **Playmobil excavators**
Private collection

Blockages in London's sewers

September 2017, London: a gigantic fatberg blocked a section of the sewage network in the heart of London. The fatberg was the result of faeces, grease, oils, wet wipes and cosmetics becoming entangled in the sewer. It was more than 250 metres long and weighed 130 tons. Samples of the fatberg were put on display in the Museum of London's permanent collection. Then in 2019 London had to deal with a 'concreteberg': an enormous, rock-hard lump of concrete weighing 100 tons. A firm of contractors in a hurry had illegally poured concrete down a street gully.

8.14 **Short film about the fatberg in London's sewers, 2017**
Museum of London

8.15 **Underground camera shots of the 'concreteberg', *Evening Standard*, April 18th 2019**

As well as contaminated water, a great deal of waste finds its way into the sewers via gully grates and toilets. This leads to blockages.

8.16 **Cut-away model of a gully filled with objects found when cleaning dirty gully grates** Farys

8.17 **Remains of plastic bags in Brussels' sewers** Tchorski

Rats in the city

Where there are sewers, there are rats. They have adapted fully to the urban environment. Down in the sewers the rats find food and they are inaccessible to predators. However, the rat populations can be a nuisance and professional rat-catchers are employed, eliminating the rats with traps and poison. Occasionally, they have to resort to heavy artillery too. Rats are still controlled for reasons of hygiene and because their gnawing and digging habits make them a nuisance.

8.18 **Brown rat (*Rattus norvegicus*)**
The World of Kina, Ghent

8.19 **Ambrosius van Zwol made this figure of a rat poison seller and his helper in 1660.**
Rijksmuseum, Amsterdam

or

Traditional rat trap of the deadfall type
Unlike industrially made traps, this one was made by hand using wood and string. Mendop, Bruges

8.20 **Rat-catcher** rarehistoricalphotos.com

8.21 **Poster about the eradication of rats, 1990** Mendop, Bruges

8.22 **Rat poison in the sewers in Brussels** Tchorski

8.23 **Newspaper cuttings from the last decade about man'sattitude to rats** Mendop, Bruges

8.24 **Photographs of Brussels' sewers**
Riolenmuseum / Musée des Égouts, Brussels

Maintenance

Maintenance work is necessary to keep sewers operational. An army of sewage workers is involved in cementing masonry, repairing leaks and removing sewage sludge. In the sewers of Paris and Brussels, for example, special carts were used for removing sewage sludge, their wheels resting on the tracks on either side of the sewer channel. These little carts were equipped with a lowerable flap which was exactly the same shape as the channels. With the flap lowered, the cart was propelled downstream by the water pressure, thereby pushing forward all the sludge on the bottom of the channel and cleaning the sewer. In sewers which were completely round, wood or metal cleaning balls were used. Today maintenance work is automated wherever possible. Sewer robots fitted with cameras are used to inspect narrow sewer pipes.

8.25 **Photographs of Brussels' sewers**
Riolenmuseum / Musée des Égouts, Brussels

8.26 **Boots worn by sewer workers in Brussels**
Riolenmuseum / Musée des Égouts, Brussels

8.27 **Sewer ball for cleaning the sewers, first half c.20**
Mission Patrimoine professionnel de la Ville de Paris

8.28 **Ghent's sewage cleaners' New Year cards, 1889–1890**
House of Alijn, Ghent

8.29 **The 'sewer dogs' of Nice (France) were trained to run through the narrow sewer pipes to keep them clean, 1931** Spaarnestad Photo

8.30 **Model of an electric locomotive with truck used to clean the sewers of Paris, end c.19**
Mission Patrimoine professionnel de la Ville de Paris

8.31 **Universal robot for sewer cleaning. Different job-specific tools can be mounted on its head, 2019**
Sewer Robotics, Poeldijk

Dehydration of the underground

One of the big problems concerning our sewer system is that the underground is gradually drying out. In urbanized areas rainwater, which used to seep slowly into the soil, now drains off roofs, car parks, roads and all manner of hard surfaces into the sewer and is carried away to rivers and canals. The latter are often straightened and their sides hardened, so that water cannot seep through the banks into the ground either. Consequently, most of the rainwater is carried straight off to the sea rather than flowing to the many peaty soils which used to act as sponges for the water. Flanders is one of the most built-up regions in the world and consequently the whole Flemish Region is having to deal with dehydration phenomena. The groundwater level is falling, which is problematic for agriculture and can also lead to ground subsidence on clay soils which contract as a result of dehydration.

8.32 **Article from *De Standaard* of August 14th 2019 about homes subsiding as a result of drought**

8.33 **Risk map of decaying piles as a result of the falling groundwater level in Rotterdam, 2019** NRC

8.34 **Schematic representation of the groundwater level** Rotor

8.35 **Map of Flanders indicating the built-up density, 2019**
According to the most recent figures, Flanders is one of the most densely built-up regions in Europe. This refers to the surface area taken up by buildings and roads.
Architecture Workroom Brussels

Infrastructure

9 For centuries cellars have been important underground structures in the city. Cellars are primarily designed to keep the superstructure stable and dry. Sometimes they also provide useful storage or serve as a refuge.
Technological progress has made it possible to build ever more intensively underground and on a larger scale. This is done partly to increase the quality of life above ground and because space here is at a premium. The underground is attractive to both government and individuals in that it provides scope for further expansion. It is also being explored as a way of improving traffic flows. For example, underground rail networks allow us to travel quickly and easily from one side of a city to another, while cars are led under busy junctions or left behind in underground car parks.
The desire to build underground warrants serious consideration. Its impact on the groundwater level and on underground ecosystems is considerable and gradually the underground will reach saturation point.

Ice cellars

Before the advent of the refrigerator, those who could afford to do so would have an underground ice cellar built. Large blocks of ice were imported, often from Scandinavia, and stored in those cellars. As and when required, smaller blocks of ice were transferred to vessels to keep food and drink cool. Most ice cellars are found on country house estates, but they are also still found in cities, where they were usually attached to a brewery or patisserie. The Donny-Baertsoen lemonade and water factory on Sint-Pietersnieuwstraat had two large ice cellars.

9.1 **Crate and bottle of Blandin mineral water** Museum of Industry, Ghent

9.2 **Ice blocks being unloaded from a ship on Muinkkaai. They were taken to the ice cellars via an underground tunnel, ca. 1870**
Museum of Industry, Ghent

9.3 **Design sketch for Emmaus castle on Sint-Pietersnieuwstraat, also featuring the ice cellars, ca. 1870**
Museum of Industry, Ghent

Water storage

9.4 Not only ice but also drinking water was kept in large reservoirs in the urban underground. Brussels has several underground reservoirs for the supply and distribution of drinking water. They are part of the drinking water system that was developed in the second half of the nineteenth century. In 1855 a huge supply reservoir was built on Kluisstraat / Rue de l'Ermitage in Elsene/ Ixelles. River water is conveyed here via underground aqueducts from the River Hain. From the supply reservoirs the water goes to distribution reservoirs, like the one on Generaal Lemanstraat / Rue Général Leman in Etterbeek (1877).

Archives de la Ville de Bruxelles / La Fonderie, Sint-Jans-Molenbeek / Molenbeek-Saint-Jean

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For when the bomb falls

In the aftermath of the earthquake that almost wiped the whole of Tokyo off the map in 1923, Japanese engineers dreamt of subterranean rather than high-rise apartments which would protect their occupants from catastrophes above ground.
In 1950 the American government began to prepare the American people for a possible nuclear attack by the Russians. In the 1960s the realization grew that the danger would come mainly from radioactive fall-out. Only shelters deep under the ground or with thick concrete walls could offer protection. In that period, mass underground nuclear fall-out shelters were built, not only in the United States of America but also in Europe. Numerous publications appeared about building and equipping these shelters. Stands at 'ideal home' shows displayed model air-raid shelters until the 1980s.

9.5 ***Popular Science*, March 1951**

9.6 ***Life*, January 1962**

Private collection

9.7 **Utopian project for a huge nuclear shelter under Manhattan (New York, USA), designed by architect and urban planner Oscar Newman, 1969**

Illustration by Jean Lagarrigue in *Esquire*, December 1969

9.8 **The 1,500 m2, luxury atom bomb shelter under Jerry Henderson's villa in Las Vegas, 1979**

Realtor

9.9 **Utopian air-raid shelters, *Popular Science*, June 1934**

9.10 **3D visualization of the command and communication bunker in Citadelpark**

In the run-up to the Second World War, the Belgian government had a command bunker built in Citadelpark from where military operations could be organized. After the war, the bunker was taken over by the Civil Defence Agency. The sirens warning the city of a nuclear attack were operated from there. When the Cold War came to an end, the bunker fell into disuse.

Real Visuals

Bunkers in Ghent

In 1940, after the outbreak of the Second World War, the city of Ghent set up the Department for Public Shelters, which was responsible for all the public refuge structures and for checking private shelters.

In 1944 greater Ghent had 129 bunkers and air-raid shelters and 129 trench shelters, able to accommodate 98,450 people. All school buildings also had shelters, which those living roundabout could also use. When many of Ghent's playgrounds were renovated recently, the forgotten shelters were rediscovered.

9.11 **Article in *Het Laatste Nieuws* of July 27th 2018 about a WW2 air-raid shelter which was discovered under the playground at a primary school in Ghent**

9.12 **Plan of the shelters in Ghent, drawn up by the Department for Public Shelters, 1943**
Ghent Archives

9.13 **Plan of the shelter under the municipal Ten Berg primary school in Sint-Amandsberg, designed by Antoine Rooms, 1939**
Ghent Archives

9.14 **Entrances to underground shelters in the Ghent area during the Second World War**
Ghent Archives

Commercial underground development

The PATH in the Canadian city of Toronto began as the basement of a department store in 1900 and has since become the largest underground pedestrian network in North America. The 30-kilometre-long labyrinth serves many different purposes, connecting shops, office blocks, hotels, garages, schools, apartment buildings and cultural venues. No fewer than 2,500 people work in this underground city, 360,000 commuters hurry to the metro and 103,000 employees go up to their office towers every day.
In Tokyo there are similar scenes in the subway stations, some of which are among the busiest in the world. The Japanese artist Tomoyuki Tanaka creates ballpoint pen portraits of these stations. The drawings are extraordinarily accurate and give the impression of being able to look through the buildings with X-ray imaging.

9.15 **The Path underground shopping arcade in Toronto (Canada)**
City of Toronto Archives

9.16 **Illustration of an underground railway station in Tokyo by Tomoyuki Tanaka**

9.17 **Illustration of an iceberg house, Ben Hasler**
In London regulations about what can be built above ground are very strict. So many wealthy homeowners extend their homes underground. These homes are known as iceberg houses because, like icebergs, only the top is visible and most of the space lies under ground level.
This drawing represents such a house including a swimming pool, a yoga space, a sauna and an underground garage with car lift.
According to the law in the United Kingdom, as in Belgium, you own all the ground under your building all the way to the centre of the earth.

Rise and fall of the underground car park

Underground car parks are a post-WW2 phenomenon. They started to become popular in the United States of America in 1950. The American government supported their construction if they could also be used as air-raid shelters. In Europe they were actively promoted by some engineers and by the cement lobby. Gradually the realization dawned that all those car parks in city centres act as a magnet for more and more cars and so pose a problem rather than offer a solution. When the plans were published for a new car park under the Emile Braunplein in the heart of Ghent in 1997, protests mounted, a referendum was held and the project rejected. Today urban planners are calling for a ban on building more multi-storey car parks and asking for thought to be given to repurposing existing car parks. An old underground car park in Paris is now used for growing mushrooms, chicory and other plants.

9.18–9.19 **Jordi Farrando / Technum / Signum / Romain Berteloot, maquettes for a car park under Emile Braunplein, 1997** STAM

9.20 **Newsreel about excavation work for a car park under Vrijdagmarkt in Ghent, 1982** Daska Films / Ghent Archives

9.21 **Article about repurposing underground car parks in the city centre, in *Ruimte*, 2019**

9.22 ***L'Encyclopédie du monde souterrain*, 1947–1973**
Ghent University, Faculty of Engineering and Architecture library

9.23 **Cultivating mushrooms in an underground limestone quarry in Paris, ca. 1900**
Jacques Boyer / Roger-Viollet

9.24 **Cultivating mushrooms in an underground limestone quarry in Paris, 1912**
Institut national de l'audiovisuel

9.25 **Film presenting the organic farm La Caverne in Paris, which has been growing vegetables in a former underground car park since 2017**

Forerunner of the hyperloop

In 1870 the American inventor Alfred Ely Beach (1826–1896) put up his own money to build a new underground mode of transport: the Beach Pneumatic Transit. He linked stations under Broadway (New York, USA) by means of a tubular tunnel through which a contraption shuttled backwards and forwards running on pneumatic power. The demonstration model was a success, clocking up 400,000 test runs in the first year. But opposition from politicians and a stock market crash in 1873 thwarted plans for an extensive network. It was 1904 before the New York subway with electric trains materialized. The Beach Pneumatic Transit is reminiscent of the Hyperloop, a concept Elon Musk came up with in 2012. The Hyperloop is a pneumatic tube for transporting people and goods.

10.1 **Plans and illustrations of Alfred Ely Beach's Beach Pneumatic Transit, 1870** *Scientific American*

10.2 **Testing a pneumatic system designed to speed up the transportation of mailbags, 1861**
The system was used in London from 1863 to 1874. Wikimedia Commons

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Constructing the New York City Subway

Building work on the subway in New York began in 1904. Much of the excavation work was done in the open air with the so-called 'cut-and-cover' method, whereby a deep trench is cut and then roofed over. This technique is less risky than digging a tunnel, but not without its challenges nevertheless. The groundwater has to be pumped away, sewers and water supply lines have to be re-routed, etc. Huge quantities of wooden beams and trusses are required to support the trenches. Tunnel boring machines with shields were only used for a number of deeper tunnels.

10.3 **Building the New York City Subway**
New York Transit Museum

10.4 **Building the New York City Subway**
New York Transit Museum, New-York Historical Society

London Underground

The London underground, or 'Tube', is not only the oldest in the world, at 400 km it is also the longest. The first lines came into operation in 1863 using steam locomotives. Most of the tunnels were excavated using circular tunnelling shields barely larger than the trains. In maquettes the intricate jumble of tunnels resembles intestines. Cut-away diagrams of the London underground stations are also referred to as 'stomach diagrams'. The underground stations were widely used as public air-raid shelters during the Second World War. The Londoners sheltering there were then attacked by a strange mosquito, the *Culex pipiens c. molestus*, a variant of the above-ground species of mosquito, the *Culex pipiens*, which is evolving into an independent species. It has adapted to life in the underground and feeds exclusively on the blood of rats, mice and people.

10.5 **Maquette of Westminster underground station, ca. 1995**
Scale 1:400
London Transport Museum

10.6 **The London underground mosquito (*Culex pipiens c. molestus*)**
Wikimedia

10.7 **Aldwych underground station, used as an air-raid shelter in 1940**
Imperial War Museum

10.8 **Real-time map of the London underground** Matthew Somerville

10.9 **'Stomach diagram' of Piccadilly Circus underground station by Douglas MacPherson, 1928**
London Transport Museum

10.10 **Sign for Leicester Square underground station, 1935**
The clear design of the London underground logo, also used for the station signs, is world famous. The typeface, Johnston, was specially designed for the London underground in 1913.
London Transport Museum

Métropolitain Paris

The Paris metro was built for the World Fair in 1900. The Compagnie du chemin de fer métropolitain de Paris, a company owned by the Belgian Baron Empain, was responsible for constructing and running it. When it came to excavating the tunnels, which are larger than those of the London underground, little use was made of the shield tunnelling method. Much of the excavation work was carried out as in the mines and using timber planks and struts. The illustrator Louis Poyet made a series of striking cut-away illustrations of some of the deepest and most spectacular metro stations in Paris.

10.11 **Illustration of the metro under Place de l'Opéra by Louis Poyet in *Le Monde souterrain*, 1950**
Cité de l'Architecture et du Patrimoine, Paris

10.12 **Illustration of the Abbesses metro station by Louis Poyet in *Le Monde souterrain*, 1950**
Cité de l'Architecture et du Patrimoine, Paris

10.13 **Crickets live in the warmest lines of the Paris metro**

10.14 **Workers in the tunnelling shield during construction of the Waasland tunnel under the River Scheldt in Antwerp, 6.10.1931**
The contractor for this work was Franki, the company of Edgard Frankignoul, who invented the Franki pile.
FelixArchief / Antwerp Archives

10.15 **Thames Tunnel peepshow, 1851**
This concertina diorama represents the first tunnel under the Thames in London, which was built between 1825 and 1843. Initially the tunnel was intended to facilitate freight traffic between the two banks of the Thames so that it no longer had to be transported by ship. But the Brunels, who designed the tunnel and drove the project, didn't have the funds to build access ramps for vehicles on both sides. In the end, there was only pedestrian access to the tunnel, so for a long time it was more of a tourist attraction. Souvenirs went on sale, like this concertina diorama. In 1865 the tunnel was sold to the East London Railway. The access ramps were built and soon stream locomotives were

travelling through the tunnel. Today the tunnel is used by underground trains between Wapping and Canada Water stations. Brunel Museum, London

10.16 **Michael Wolf, *Tokyo Compression*, 2010**
In 2010 art photographer Michael Wolf (1954–2019) photographed people in the subway in Tokyo for his series *Tokyo Compression*, which shows individuals pressed against the windows of the crowded trains. The disquieting images illustrate what it means for millions of city dwellers to live together in a dense urban centre.

Metro in Ghent

In 1976 Ghent city council presented plans for the construction of a pre-metro line from St Peter's railway station to the city centre. This would involve partially filling in the River Leie/Lys. However, the plans drew strong criticism and nothing came of them.

10.17 **Plans for the Ghent metro in *Openbaar vervoer in de Gentse agglomeratie* (Public transport in the Ghent agglomeration)**
STAM

10.18 **Protest against the plans for a metro in Ghent, 1976**
Amsab-ISG, Ghent

10.19 **Newsreel about the plans for a metro in Ghent, 1976**
Daska Films / Ghent Archives

10.20 **Poster of the protest against the Ghent metro, ca. 1976**
Ghent University Library

The smart city?

11 Recent scientific research has shown that trees in a wood share information and nutrients underground. The network of roots and mycorrhizal fungi is so extensive that scientists sometimes talk about a Wood Wide Web, by analogy with the internet. The image of the smart wood evokes parallels with the image of the smart city, where buildings are connected by means of a complex underground network through which energy, information, raw materials and waste flow. Sensors ensure the detailed monitoring of all movement and communication. But there are also important differences: the smart city consumes raw materials on a massive scale. These have to be brought in and they generate vast quantities of waste, which then have to be dumped elsewhere. The ideal model of the circular city, whereby — as in a wood — waste matter can be converted on the spot into nutrients or building materials and repurposed, remains an unrealized dream.

11.1 **How trees secretly talk to each other, 2018**
BBC News

11.2 **Promotional video for a part of the 'smart' city: automatic detection of leaks in water pipes**
Sensor DDS LID

11.3 **The Wood Wide Web: trees are in contact with each other via their roots and the hyphae of fungi. A wood is a closed-loop ecosystem**
Rotor

11.4 **The 'smart' city aspires to a circular economy, but continues to deliver its construction materials over a distance of thousands of kilometres and to dump its waste in far-flung continents.** Rotor

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↳ www.stamgent.be

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