One of the principal attractions of Britain to the Romans was its mineral wealth. The Empire had for some time imported iron, lead and silver from Britain. But it was apparent that not only were there reserves far in excess of supply, but that it could be more efficient and cheaper to bring the operations under their direct control. In particular iron from the Weald and the Forest of Dean, and lead from the Mendips, from which the silver was extracted, were the main draw.

The main production was as follows:

Iron	The Weald (some 40 sites identified), Forest of Dean (The Scowles, Lydney Park, Puzzle Wood)
Lead	The Mendips, followed by North Wales and the Pennines
Silver	as above, extracted from the smelted lead
Gold	Dolaucothi (Pumsaint, between Llandovery and Lampeter)
Copper	Cornwall, Llanymynych (west of Shrewsbury), Anglesey (Parys Mountain), Great Orme's Head, Alderley Edge
Tin	Cornwall
Salt	Cheshire, Droitwich
Stone	widespread

In most cases, evidence has been found for Iron Age working, and sometimes even back to the Bronze Age, but it seems the Romans revitalised operations to increase production dramatically, no doubt using their considerable experience from elsewhere in the Empire. Still there does not seem to be evidence of any revolution in mining techniques: these were already established in the Iron Age. Not that the Romans would have dirtied their Imperial hands however: the local mineworkers simply became Roman slaves or in those areas where terms had been agreed, employees, probably augmented by slaves they had picked up along the way.

The need for efficient transport to population centres and coastal shipping points led to the building of new roads. Roads directly related to mining are known in the Forest of Dean, also in the Weald. In some cases these followed earlier tracks; in some, as at Blackpool Bridge in the Forest, they have become overlaid by medieval roads. The shipping of product to the continent was from a number of Channel ports: Pevensey and Hengistbury Head are known to have been important.

Iron

The chief ore in the Weald was siderite, (Iron carbonate, $FeCO_3$) which occurred as irregular lenticular beds in the Lower Cretaceous sands and clays of the Weald. Extraction was opencast, by excavation of pits or quarries, each being backfilled with spoil from the next when exhausted. Apart from the iron ore, much timber was needed for the production of charcoal, and this was plentiful in this densely wooded area.

Once the raw ore was removed from the mine, it would be crushed, then washed. The less dense rock would wash away, leaving behind the iron

ore, which was then smelted using the bloomery method. The bloomeries were generally sited in open hilltop locations and consisted of a circular bank of clay with low-level air inlets where the wind could create a natural draught. The ore was heated up to 1500°C using charcoal, when it separated into metallic iron and slag. The remaining slag was removed and generally dumped. After being smelted, the iron was sent to forges, where it was reheated, and formed into weapons or other useful items.

In the Forest of Dean the chief ores were hematite (Iron oxide, Fe_2O_3), goethite (hydrous Iron oxide, FeO(OH)) and limonite or ochre (hydrous Iron oxides, $2Fe_2O_3.3H_2O$), extracted from the Crease Limestone of the Lower Carboniferous. There it occurred as irregular infillings of hollows in the upper surface of the Crease, down joints and fissures, and in “churns” (infilled solution features or potholes). Ore was transported to a huge smelting site at Ariconium, Weston under Penyard, where many bloomeries have been excavated.

Iron was also extracted at Water Newton, Cambridgeshire, just to the west of Peterborough. These would be the siderite ores of the Lower and Middle Jurassic limestones which were worked extensively opencast further north in Lincolnshire in the first half of the 20th century.

Lead and Silver

Lead mining in the Mendips is thought to have begun in late Iron Age times, but large-scale working only began with the Romans. By 46 AD they were established at Charterhouse and Ubley, working lead, of which stamped ingots have been found there, at Bedminster, in a Roman warehouse excavated on the banks of the Thames in London, and on the continent. These are indentified by the inclusion of VEB (probably short for Vebriacum - modern Ubley) in the cast inscription. These are to be seen in the British Museum, the Wells and Somerset Museum, and I understand, in Taunton Museum. These workings were supported by a small fort and an amphitheatre.

The Romans also mined for lead on a large scale in the Pennines and North Wales. Roman ingots have been found at Greenhow Hill, Nidderdale and Hurst, Swaledale, in Yorkshire. Slave labour was certainly used at Hurst.

By 70AD the output of lead from Britain exceeded that of Rome’s largest lead mining complex, Rio Tinto in Spain.

The lead ore galena (Lead sulphide, PbS) occurred in veins following fault and joint lines in the limestones and associated sandstones of the Lower Carboniferous. Since veins were mostly vertical or near-vertical, and sporadic in occurrence, the chief problem was in finding them. Since the Carboniferous Limestone generally forms hilly uplands, it was possible to expose them by “hushing”. An earth dam was built, filled with water, then breached, to cause a rush of water which scoured a channel down the hillside, exposing fresh rock together with any ore-bearing veins. These were then broken up by fire-setting, and the ore extracted. Horizontal tunnels could then be driven into the veins exposed in the side of the hushes, or from shafts sunk from surface on the line of the vein.

The veins also contained the “gangue” minerals calcite, barytes and

sometimes fluorspar. The ore was first dressed to remove these, then roasted to convert it to lead oxide. As the temperature was increased this melted and ran through the bed of charcoal which reduced it to lead, which collected at the bottom and was run off into moulds.

Silver was a very valuable commodity in ancient Rome, used for coinage and jewellery. In Britain it was derived by further processing of the refined lead, since most British lead was argentiferous, sometime up to 2%. This was said to be the principal reason for the interest in lead.

Gold

Gold is almost unique among metals in that it occurs not as a mineral, but chiefly as native gold, albeit invariably alloyed with a small part of copper or silver. It occurs disseminated within veins of quartzite.

Gold mining was established at Dolaucothi at Pumsaint, between Llandovery and Lampeter. The Romans discovered the Dolaucothi vein soon after their invasion, and they used hydraulic mining methods to prospect the hillsides before discovering rich veins of gold-bearing quartzite. The remains of the several aqueducts and water tanks above the mine are still visible today. The tanks were used to hold water for hushing during prospecting for veins, and it involved releasing a wave of water to scour the ground and remove overburden, and expose the bedrock. If a vein was found, then it would be attacked using fire-setting, a method which involved building a fire against the rock. When the hot rock was quenched with water, it could be broken up easily, and the barren debris swept away using another wave of water. The technique produced numerous opencasts which are still visible in the hills above Pumsaint or Luentinum today. A fort, settlement and bath-house were set up nearby in the Cothi Valley. Long drainage adits were dug into one of the hills at Dolaucothi, after opencast mining methods were no longer effective. Once the ore was removed, it would be crushed by heavy hammers, probably automated by a water wheel until reduced to a fine dust. Then, the dust would be washed in a stream of water where the rocks and other debris would be removed, the gold dust and flakes collected, and smelted into ingots. The ingots would be sent all across the Roman world, where they would be minted or put into vaults.

The Roman mines at Dolaucothi are now owned by the National Trust and can be visited. A fragment of an underground water-wheel was found similar in design to a reverse overshot water-wheel used for raising water in the mines at Rio Tinto.

Copper

Copper and tin understandably have a longer mining history than most minerals, being the constituents of bronze, hence without them the Bronze Age would have been impossible.

Llanymynech Hill is one of Wales's earliest mining sites. Copper was smelted here in the Bronze Age, and the Romans developed copper and lead mines. There have been suggestions that Llanymynech hillfort may

have been built to protect the sources of copper ore which lie within its interior. There is evidence to suggest that these ores were being mined and used for the manufacture of bronze weapons and implements from the later Bronze Age onwards and there is a cave known as the Ogof inside the hillfort which was probably a Roman mine; a hoard of 33 coins dating between 30 BC and 161 AD was found there. At least ten shafts were formerly visible before landscaping, together with a large number of shallow pits and shaft mounds. Lead and/ or copper processing probably took place on the hilltop as evidenced by the former existence of processing spoil heaps prior to landscaping for the golf course. Excavations in 1981 revealed evidence of metalworking hearths relating to the reworking of smelted local copper ores. This activity has been dated to the second and/ or first centuries BC by radiocarbon dating. It has already been proved elsewhere in Britain that copper was mined as far back as the Bronze Age, using primitive antler and bone picks to prize open cracks in the rock made by firesetting. This technique involved lighting a fire against the rock, causing it to expand with the heat. When water was thrown against it, the rock suddenly contracted and split. Copper would originally have been dug out of deep trenches but when the deposit became too deep, it had to be followed underground. When the Romans arrived in the area, they found an existing copper mining industry and quickly exploited the Ogof for their own use. They would have had engineers with experience in other Roman mines and this allowed them to develop the workings in a more logical pattern. Mining was basically the same with firesetting and picking, although they used iron picks and wooden shovels with iron tips. Copper ore was placed in small wicker baskets and dragged out along the low passages. Slaves would have been used as miners and labourers and these would rarely see the light of day, being kept imprisoned in the mine. The lack of basic hygiene and ventilation would probably mean that the slaves did not lead long lives. Over the years, a great many Roman artefacts have been found in the mine including a hoard of silver coins found by some schoolboys. Another strange feature has been the discovery of burials in and around the mine and bones may still be found amongst the rubble on the floor.

Parys Mountain, Amlwch, Anglesey
These mines have been worked since the Bronze age, 3500 years ago. During Roman times they were thought to be the largest man-made excavation in the world. During the 18th and 19th century they were the largest copper mine in the world.The underground workings were last mined in the early part of the 20th century. The mining complex exists to this day as a huge excavation, and with the kind permission of The Marquis of Anglesey and Anglesey Mining PLC some areas of the mine have been reopened for exploration.

Alderley Edge, Cheshire has a similar history to Llanymynech Hill. The mines are still open but no longer worked.

Tin
Tin is derived almost solely in Britain from the oxide cassiterite, SnO_2,

which occurs in quartzitic veins around the edges of the granites of Cornwall and Devon. However earlier workings were based on fragmented cassiterite laid in alluvial deposits, and it is likely to be in this form that most of the Roman work would have been done. Cassiterite has a high tin content, around 70%, so it is possible much of the ore would have been transported to more wooded areas with more plentiful charcoal, for smelting.

The tin resources are said to have been a reason the Romans invaded Britain but they had control of mines in Spain and Brittany in the 1st and 2nd centuries. Later production in Spain was curtailed, probably by raiding. Production in Britain increased in the 3rd century, for use in coinage, and there was extensive use of tin in pewter manufacture, at Camerton in Somerset for example. Cornwall and West Devon are areas which are less Romanised than many other parts of Britain and it may be tin mining was in local hands with tin purchase by the imperial authority. A possible official stamp has been identified on the Carnington tin ingot. A number of tin ingots have been found in Roman contexts such as 42 found in a wreck at Bigbury Bay in 1991–92.

A site in the Erme valley, Devon, shows sediment aggregation in late Roman and Post-Roman times due to tin mining on Dartmoor. There is a peak in activity between the 4th and 7th centuries. Tin slag at Week Ford in Devon has been dated to 570 – 890 AD.

St Piran (patron saint of tinners) is said to have landed at Perranporth from Ireland about 420 AD.

Salt

Salt (Sodium chloride NaCl) has always been important for human life. Salt occurs naturally in two forms, rock salt and salt evaporated from sea water. The Romans brought with them their salters, ready to harvest salt from the sea, but on finding ready terrestrial supplies and a wetter, cooler climate than southern Europe not conducive to extraction by evaporation, these were mostly sent home.

Rock salt occurs in often thick and fairly pure beds within the red mudstones of the Saliferous Beds of the Triassic Mercia Mudstone formation (formerly known as the Keuper Marl). The Saliferous Beds reach their full development in only three areas of the British Isles: around Northwich and Middlewich in Cheshire, Droitwich in Worcestershire, and Carrickfergus in Co Antrim, but the Romans did not reach Ireland. The main difference between the Cheshire and the Worcestershire saltfields is that a large part of the Cheshire salt lies above the water table, allowing it to be mined by pillar-and-stall workings, and these were already in use before the arrival of the Romans. In Worcestershire however, as in the remainder of the Cheshire field, the salt lies below the water table, and is highly soluble in water. The Romans discovered strongly saline springs at Droitwich, which they exploited by digging large pits lined with timber, from which the brine was recovered by baling.

Processing was very simple, involving only crushing of the rock salt or evaporation of the brine. The present-day salt industry uses the same

methods. Distribution was probably by pack-horse trains along the designated salt roads radiating from both centres, to centres of population and for shipment to the continent, as well as by river. (A good local example is the Saltway from Droitwich to Lechlade) The Romans were known for the prodigious loads they expected their animals to carry: roughly twice the load of the medieval mules.
Some Roman mining implements are displayed in the Salt Museum in Northwich.

Stone
The Romans were the first people in Britain to use stone widespread for building. Wherever the Romans built towns and town walls rather than earth ramparts, a source of building stone was required, and finer stone was needed to build their roads. Stone was heavy and bulky, and a relatively low-value commodity, hence it was not economic to transport it far, and quarries were opened at the closest possible locality to each development.
For example in Chester they used the local Triassic red sandstones, in York the local Permian Magnesian Limestone, in Lincoln the local Jurassic limestones, in Exeter the local Devonian red sandstones and dark volcanic intrusive rocks. In Gloucester they used the thick limestones from the Cotswold escarpment.
Roman-worked quarries are not often easy to identify. In Cirencester the amphitheatre was built in a disused quarry, and in 1985 I found one in the Querns Hill area during a ground investigation for new offices for Cotswold District Council, infilled with clay and with the tool-marks still visible on the stepped rock face. The source of stone for Gloucester has not been identified with any certainty. The Cranham area has been proposed, with the modified River Twyver suggested as a means of transport. This had a number of earth dams constructed along its course, and it is easy to surmise that the stone blocks were fastened to large timber sledges/rafts for pulling downhill to the stream, using timber rollers where necessary. With all sluices closed water levels would build up in the upper reaches, enabling the raft to be floated down to the first dam, pulled over the top of it and down the face to the next reach, which would then be flooded by opening the sluice above, and so on. Unfortunately it has not been possible to date any of the earth dams to prove a Roman origin. Another site of long-term quarrying is at Birdlip, below the George Inn, with the attraction of Ermine Street which passed right by. Other sources of stone were the thin limestones of the Lower Lias and the Pennant Sandstones of the Forest of Dean, which could exploit transport systems developed for Iron.

Sources
The above digest has been extracted almost wholly from a wide variety of sources, some of them online and some unattested. A small part on lead, and the section on stone, are my own work.

Ted Wilson, 19 May 2015