#### Fact Sheet 5

## **Principles of stone extraction**

In all stone quarry situations the extraction phase is based on one or combinations of three fundamental principles:

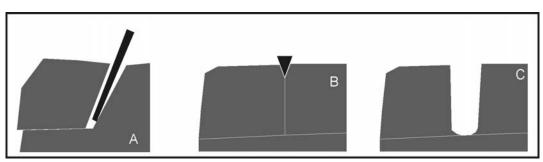
- 1. Levering; expanding open fractures by inserting levers, crowbars or stones
- 2. Splitting; creating fractures, preferable planar, by strokes (i.e. sledge hammer), wedging; heating or blasting with explosives
- 3. Channelling (carving); making channels in the rock by carving with hammer and chisel, pickaxe or stone tools, heating with fire, sawing or drilling

Levering may be described as the "simplest" way of extraction, involving the expansion of natural cracks or other planes of weakness (such as bedding planes) using various tools.

Splitting may be defined as the act of generating new fractures for extracting rock. This may be done by percussion (stroke), inserting wedges of some kind in prefabricated holes or by heat. In a modern context, splitting is mainly done by detonating explosives in drillholes. Although splitting techniques may be applied on most rock types, it is working best on hard siliceous (quartz-

rich) ones. Partly because they in general display the most brittle behaviour, but also because it is a well documented fact (and experience among quarrymen) that siliceous rocks (granite in particular) have well defined preferred splitting directions defined by microfractures in quartz. Splitting by heating is caused by a combination of thermal expansion properties and brittle behaviour. It works best on quartz-rich rocks due to the well known but poorly understood change of mechanical properties of quartz when heated.

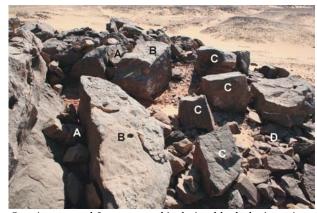
Channelling is the third fundamental principle. Channels in the rock are made by removing the rock mass by chiselling, picking, sawing or heating. In most soft stone quarries from the Bronze Age onwards, channelling is the most important extraction method. In most cases, channelling is combined with other methods. For instance, channels are made perpendicular to the natural layering of the rocks, and when the block is free on four sides, it is split with wedges ("trench and wedge" method) or levers/crowbars inserted in chiselled grooves ("Minoan technique") or by inserting wooden wedges in the channels themselves, creating shear stress along the block's bases.



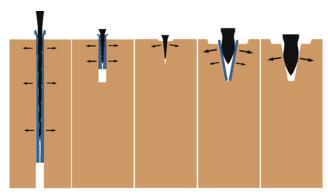
Three basic principles of extraction from bedrock. A) levering, B) splitting and C) channelling.

Principles of extraction and associated process/features

Principle	Process	Tools	Toolmarks
Levering/extraction	Crack expansion	Logs	Hardly any
on fractures		Crowbars	
		Stones	
Splitting	Percussion	Stone	Percussion marks, plumose marks on
		hammers/pounders	cracks
		Chisel	
		Pick	
		Sledge hammer	
	Wedging	Simple iron wedges	Wedge marks of various shapes
		Plugs and feather	
		wedges	
		Wooden wedges	
	Heating	Fire	Surface parallel flaking
	Blasting (M)	Explosives	
Channelling	Carving	Chisel	Straight parallel
		Pick	Curved parallel
		Stone tools	Pointed grooves
	Sawing	Blade	Sawn surface, straight grooves
		Wire	Sawn surface, curved grooves
	Drilling (mainly modern		
	Heating (mainly modern)	Fire	



Opening natural fractures and isolating blocks by inserting stones (A). The blocks are then further split in several steps (B and C). Aswan, Egypt.



Wedging techniques. The two on the left side ("plug and feather") are put in premade drillholes (modern).

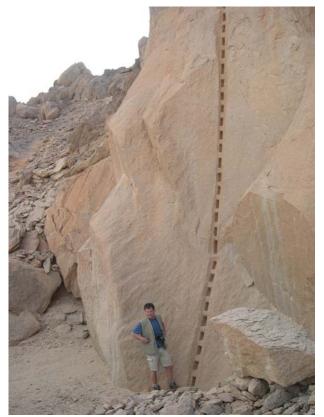


Splitting granite with small iron wedges (Vigo, Spain).



Roman wedge-marks from splitting, Aswan, Egypt.

# QuarryScapes guide to ancient stone quarries



Wedge-line in a Roman granite quarry, Egypt.



Percussion marks made by stone hammers for splitting a sandstone block (Dynastic Egypt).

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Percussion marks made by chisel for splitting a sandstone block. Roman Period, Egypt.



Channel in granite quarry, Egypt, made by stone hammers, possibly combined with heating.

## QuarryScapes guide to ancient stone quarries



Channel made by Roman pick in limestone quarry. Sagalassos, Turkey.



Channels around limestone block made by bronze chisel, and premade holes for inserting wooden levers or wedges along the base. Old Kingdom, Giza, Egypt.

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Channel in sandstone made by Roman iron pick and premade holes for inserting levers or wedges to split the block along its base. Roman Period, Gebel el Silsila, Egypt.



Extraction of marble slabs by chiseling channels around the blocks and splitting along their bedding plane by pointillémethod (repeated strokes with a pointed chisel along the splitting plane). Byzantine marble quarry, Thassos, Greece.