

ACKS Mining

This work is basically derived from the AD&D 2E Complete Book of Dwarves, modified and remathed to fit into the ACKS system assumptions.

Mining

Mines are fun. They have adventures built into every nook and cranny; following the vein can very easily break you into an underground cavern full of zombies, or any other crazy thing. They're also a great alternative to mercantile ventures if PCs don't see themselves as trader moguls, but instead want to focus on a specific product. In this set of random math, they can focus on mines, and metals.

The first step is for the Judge to determine whether or not the area has any mineral veins, and if so, how many are viable to mine. This will depend on your campaign world (in the world of Athas, very few areas will have mineral veins; in the hypothetical Dwarf Heaven, every area will have multiple mines). If you do not have a detailed geological and tectonic survey of every area in your campaign world, you have two options; you can choose or roll.

Terrain Type	Mineral Veins per Hex
Clear, Grass, Scrub	1d4-1
Woods	1d2-1
River	1d2-1
Swamp	1d3-1
Mountains	2d6
Hills	1d8
Barren	1d6
Desert	1d4-1
Jungle	2d4
Underground*	1d6+1

*at a depth of 101 feet or deeper; above that, use the value for the terrain on the surface

Once the Judge knows how many veins are in an area, the next step is for them to be discovered by the potential miner (whether PC or NPC). The potential miner must make (or have made on his behalf) a Land Surveying proficiency throw to examine the hex. This throw takes one month under ideal circumstances, but may take longer under some conditions; for example, being attacked by monsters, being forced to provide your own food, inclement weather, etc, will all cause delays in the survey. If the throw fails, the character fails to find any mineral veins in the area. If the throw is successful, the character learns the number of viable mineral veins in the area, and the best location to approach one of them. The vein will be buried 1d10*10 feet below ground, and will require an initial excavation to approach. Further throws (requiring one week per throw, again under ideal circumstances) can survey the best approach to each other mineral vein. (Of course, if the area has no useful mineral veins, a successful proficiency throw learns simply that.)

It is also possible to survey underground. However, surveying underground is slower and more difficult, and will take 2 months per hex to survey and 2 weeks per hex to find additional mine approaches. On the other hand, when already underground, the amount of excavation you need to access each mine approach is much lower, a mere 2d10 + 10 feet.

Surveying a non-pacified hex should guarantee at least one random encounter aboveground, and at least two belowground. Surveying a pacified hex should roll for a chance of random encounter for wandering monsters aboveground, or twice belowground.

For every 500 feet of depth you travel underground, you may survey the hex for veins again.

Once the number and location of veins are known, it is important to know what type of vein has been found. This is not learned by the initial Land Surveying throw, but requires a successful Knowledge (geology) or Craft (mining) throw. (Or any other proficiency deemed to be appropriate by the Judge.) A failed throw results in misidentification; the Judge should roll on the Mine Type table twice, once for the true result and once for what the character believes it to be, and inform him of the false result.

Roll (d100)	Mine Type
1-45	Copper
46-60	Tin
61-75	Lead
76-85	Iron
86-90	Silver
91-93	Electrum
94-97	Gold
98	Platinum
99	Mithril*
100	Gemstone**
101+	Precious***

*(roll on Mithril Formation sub-table)

**see (Appendix 1: Gemstone Mines)

***(roll on Precious Formation sub-table)

Depth Modifiers to Mine Type

Depth	Modifier
0-100 feet	0
101-500 feet	+20
501-1000 feet	+30
1001-2000 feet	+40
2001-3000 feet	+50

Beyond 3000 feet of depth, the temperature becomes problematic to deal with. Should you be able to deal with this (it is expected to be approximately 45C/110F at a depth of 3000 feet), add an additional 10 to your roll for each 1000 feet of depth. Note that every 1000 feet of depth also increases the temperature by 10C. (The actual maximum depth before you hit mantle ranges, in the continental crust on Earth, from approximately 20 to 30 miles; unless you are fire elementals, balrogs, or other such creatures, the heat and pressure will stop you from mining long before you reach this limit.)

Mithril Formation Sub-Table

Roll (d10)	Result
1-4	Silver (highest quality)
5-7	Electrum (highest quality)
8	Gold (highest quality)
9	Platinum (highest quality)
10	Mithril

If your campaign is not using mithril or any other fantastic metal, and you roll Mithril on the Mine Type table, roll on the Mithril Formation sub-table as normal. However, if you then roll Mithril again, treat it as Platinum (highest quality).

Precious Metals Sub-Table

Roll (1d10)	Type
1-3	Silver
4-5	Electrum
6-7	Gold
8	Platinum
9	Mithril*
10	Gemstone

*roll on Mithril Formation sub-table

After you determine what type of mine you have, the next step is to roll for the quality of the ore found in this mine.

Roll (1d20)	Quality
1	1
2-3	2
4-5	3
6-8	4
9-12	5
13-15	6
16-17	7
18	8
19	9
20	10
21+	Roll on High Quality sub-table

Depth Modifiers to Quality

Depth	Modifier
0-100 feet	0
101-500 feet	+1
501-1000 feet	+2
1001-2000 feet	+3
2001-3000 feet	+4

If delving beyond 3000 feet, add an additional +1 per 1000 feet.

High Quality Sub-Table

Roll (1d10)	Quality
1-2	7
3-5	8
7-8	9
9-10	10

The quality of a mine determines what percentage of the ore is metal; multiply the quality by 10, and the ore is that percentage metal. (A range of 10% to 100%). Quality 10 ore is pure metal, not ore at all, and does not require smelting. All other qualities of ore must be smelted to separate the metal from the ore.

A mine is worked by a team of 1 master miner, 2 journeyman miners, 4 apprentice miners (these preceding characters all have varying ranks of Craft (Mining)), and 10 unskilled laborers. Together, the amount of work this team can perform in a week comprises a miner-week of work. One miner-week is the standard unit of work used in these calculations and tables. Should you prefer to use a monthly scale (miner-month instead of miner-week), multiply all appropriate numbers by 4. (This introduces a little bit of roundoff error, but it is acceptable in my mind.) Paying this mining team costs 40 gp per week.

Each type of mine has a different rate of quarrying. One miner-week extracts a variable amount of ore from the mine, depending on which type it is. Copper, tin, lead, and iron are common metals; thus, it requires 100 stone of metal to fill one load of common metal (with a base value of 200 gp.) Silver, electrum, gold, and platinum are precious metals; one load weighs only 4 stone and has a base value of 600 gp. However, that is the actual metal weight. The weight of ore required to smelt that amount of metal will vary based on the quality of the mine; at 50% quality, it will take 200 stone of ore to smelt out 100 stone of metal. The Mining Progress table shows the amount of ore that will be extracted by each miner-week of work.

Mine Type	Ore Mined per Week (Stone)
Copper	50
Tin	100
Lead	150
Iron	200
Silver	2
Electrum	4
Gold	6
Platinum	8
Mithril	32

In addition to extracting the listed weight of ore, the miners will excavate the tunnel further. A standard mining tunnel is 10 feet high and 10 feet wide. Each miner-week of work will lengthen the tunnel by 2 feet. In addition, every 10 feet of tunnel length will have shoring braces installed, to keep the tunnel from collapsing on the workers.

Once the ore is extracted, it must be smelted to extract the metal from it. This requires a smelter, and an expense of both materials and manpower. The end result, however, is that in addition to the cost of the smelter, it costs 1 gp to smelt 20 stone of common ore and 10 gp to smelt 1 stone of precious ore.

A small smelter costs 1,000 gp to set up and can process 20 stone of ore per week.

A medium smelter costs 4,000 gp to set up and can process 100 stone of ore per week.

A large smelter costs 16,000 gp to set up and can process 500 stone of ore per week.

If you do not wish to set up and run the smelters yourself, you may be able to find a smelting operation who is willing to smelt your ore for you. Failing that, you can simply sell the ore. If you wish to find someone to smelt your ore for you, use the rules for finding a shipping contract (ACKS page 144). They will charge you a base price of 5 gp per 20 stone for common ore, or 50 gp per stone for precious ore.

Multiply your weight of ore by the quality of your vein to determine the amount of metal you have after smelting. Should you not desire to smelt your ore, you can sell it as raw ore instead. Raw ore is worth 25% of the value it would hold if it were smelted. (Thus, if you had 200 stone of 50% quality tin ore, you could smelt it to make 100 stone of tin. 100 stone of tin would be worth 200 gp. Your 200 stone of tin ore is therefore worth 25% of 200, or 50 gp.)

Now that you know how your mine works in play, you need to know how long it can be worked for before it is played out. To determine this, roll 1d100. If you did not roll doubles (11, 22, 33, etc), then the mine can be worked for a number of miner-weeks equal to your roll. (Thus, if you rolled a 37, and you have a single mining team on the vein, it can be worked for 37 weeks before being played out.) If you did roll doubles, however, note your roll and roll again; the mine can be worked for a number of miner-weeks equal to the original roll, and a number of miner-months (four miner-weeks) equal to the original roll. If you rolled doubles again, roll yet another time, for miner-years. Should you roll doubles a third time, roll again, for miner-decades, and continue if you should continue to roll doubles with miner-centuries, miner-millennia, etc. As you can see, most mines will play out within a year, but some will continue to produce for generations. (A high-quality platinum mine with a duration in miner-centuries is the kind of thing kings and emperors go to war over.)

Mineral veins do not usually run in a straight line for their entire lifetime; they twist and turn. Should you care to follow the path of the vein (usually appropriate for mines that the characters are personally managing and might have underground adventures inside), use the following tables.

Mineral Vein Direction Table

Roll (1d4)	Direction
1	North-South
2	East-West
3	Northeast-Southwest
4	Northwest-Southeast

The vein will always run at least 20 feet in the direction indicated. After each 20-foot section is excavated (10 miner-weeks of work), roll 1d10 and consult the Vein Path Alteration Table. In addition, after each 20 foot section is excavated, the Judge should check for random encounters as appropriate for the terrain. (In general, it is expected that the deeper you are, the more likely a random encounter is and the more devastating that encounter will be.)

Vein Path Alteration Table

Roll (1d10)	Vein Path
1-2	Steep descent
3-4	Shallow descent
5	Curves right (1d6*10 degrees)
6	Curves left (1d6*10 degrees)
7	Continues straight
8	Shallow ascent*
9	Steep ascent*
10	Vein ends

*if this mine starts 100 feet or fewer underground, the first time this is rolled, treat as descent rather than ascent

A shallow ascent or descent climbs or falls 1 foot per 2 feet of length excavated (thus, over the course of its 20 foot length before rolling for a new direction, the elevation will change by 10 feet.) A steep ascent or descent climbs or falls by 1 foot per foot, thus 20 feet before rolling again.

If the vein's path takes it to a place where it cannot be reached (such as open air or a lake of lava), the vein ends. At the Judge's discretion, it might be possible to pick up the vein on the other side of the obstacle, such as a small gorge. If the vein ends in both direction, the mine is played out; this takes precedence over the ordinary rules for the duration of the mine.

Appendix 1: Gemstone Mines

Gemstone mines work differently from other mines. A gemstone mine will produce uncut stones of a type determined by random roll. These stones must be cut by a character with the Craft (Gem Cutting) proficiency. Uncut, they are worth only 1/10th of their cut value.

To determine what class of stone comes out of the gemstone mine, roll on the Gemstone Type table.

1-65	Ornamental
66-90	Gem
91-100	Brilliant

A gemstone mine is worked by the same team as a metal mine; one master miner, two journeyman miners, four apprentice miners, and ten unskilled laborers constitutes a single team and can perform one miner-week of work per week. Paying the mining team costs 40 gp per week.

A gemstone mine's output varies by week. The following table shows the number of gems found per miner-week, by gemstone type.

Ornamental	4d10
Gem	2d6
Brilliant	1d4-1

In addition, the quality of the gems found varies by week. For each miner-week worked, roll on the Gem Value table (ACKS core page 207). Specific gems found may be more or less valuable than the result of your single roll, but an average is accurate enough, and the average gem found in that week will have the value rolled when cut. Multiply the number found by the value rolled to determine the mine's output that week. (Remember to divide by 10 for its uncut value.)

Once the gems have been mined, they must be cut. A gem cutter may cut a value of uncut gems per month equal to his monthly gold output. (I'm not completely sold on this as a method, because it makes gem cutting pretty super profitable if you can get a source of uncut gems to actually sell to you, but I also have a problem with the idea that it would take a master gem cutter 10 years to cut a single 5,000 gp gem. Under this method, it only takes him a single year, which is still vastly longer than what I can find any reference to, but I can't find any good historical reference to use and 2E is no help, a dwarf with the Gem Cutting proficiency can cut 2d8 gems per day regardless of value.) You may hire a maximum of one team of gem cutters (one master, two journeymen, and four apprentices) per gem. (One master, two journeymen, and four apprentices working together and supervised by the master can cut 40 gp per week at a cost of 30 gp per week. Remember that the 40 gp they can cut is the uncut value of the gems; one week of work for them will produce gems worth 400 gp.)

Gemstone mines have duration and path alterations just as all other mines do. See the main Mining section for these rules.

Appendix 2: Mining Math

Mine Type	GP Value per Load	Ore Mined per Week (Stone)	Metal Weight per Load	Expected Value per Week (50% quality)	Weekly Costs	Weekly Profits	Minimum Quality for Profit
Copper	200	50	100	50	42.5	7.5	5
Tin	200	100	100	100	45	55	3
Lead	200	150	100	150	47.5	102.5	2
Iron	200	200	100	200	50	150	2
Silver	600	2	4	150	60	90	3
Electrum	600	4	4	300	80	220	2
Gold	600	6	4	450	100	350	2
Platinum	600	8	4	600	120	480	2

I have done everything in terms of weeks because I started with the Complete Book of Dwarves and it uses weeks. To transition to months, simply multiply by 4. This will introduce some roundoff error, but it is really not worth the effort to multiply by 30/7 instead. If you want to be able to use both the weekly numbers and the monthly numbers in the same campaign, clearly the lost 2 days are because of sicknesses and injuries common among miners causing you to lose productivity.

The weekly costs are smelting costs and manpower costs; a mining team costs 40 gp per week to pay, and smelting requires 1 gp per 20 stone for common ore (copper, tin, lead, iron) or 10 gp per stone for precious ore (silver, electrum, gold, platinum). You must additionally purchase a smelter. Note that the costs for smelting include both the materials required and the manpower required to man a smelter (the major difference in cost between common ore and precious ore is due to the need to hire trained men to smelt precious ore, or unskilled laborers to smelt common).

A small smelter costs 1,000 gp to set up and can process 20 stone of ore per week.

A medium smelter costs 4,000 gp to set up and can process 100 stone of ore per week.

A large smelter costs 16,000 gp to set up and can process 500 stone of ore per week.

(Math note: Each time you increase your level of smelter, you increase the price by 4x and the capacity by 5x. This is intended to make sure that it is not more efficient to stack the lower levels of smelter; you should buy the one with the capacity you need. However, I also want there to be a meaningful tradeoff, so you don't just buy a large smelter every time and just wait until you actually need the capacity.)

Roll (1d20)	Quality	Chance of Occurrence
1	1	5%
2-3	2	10%
4-5	3	10%
6-8	4	15%
9-12	5	20%
13-15	6	15%
16-17	7	10%
18	8	5%
19	9	5%
20	10	5%

Mine	Chance Below Minimum Profit Quality
Copper	40%
Tin	15%
Lead	5%
Iron	5%
Silver	15%
Gold	5%
Electrum	5%
Platinum	5%

Every week of work by a mining team (40 gp of work) cuts out 200 cubic feet of rock. In a normal 10' by 10' tunnel, this is 2 feet of length. This number was arrived at by adding up the values of work of a master, two journeymen, four apprentices, and 10 unskilled laborers, which came out to 42 gp/week; I rounded to 40. Assuming that chopping through rock is half as difficult as building a stone wall (as I assume that building a stone wall requires half investment in quarrying/dragging stone, and half in actually putting the wall together), this costs .125 gp of work per cubic foot; 200 cubic feet is only 25 GP of work. What happened to the other 15 gp of work? Shoring braces. Shoring braces require 30 cubic feet of wood (45 gp of work) every 10 feet of tunnel length (1,000 cubic feet). This increases the cost per cubic foot from .125 to $.125 + (45/1000) = .17$. 200 cubic feet at .17 gp per cubic foot is 34 gp of work. The last 6 GP is roundoff error, because I think in this case, it's better to have nice round numbers than it is to maintain perfect accuracy. Clearly, mining and excavating is a little bit harder than similar work aboveground and therefore carries a bit of a penalty with it. (If you want to follow the formulas perfectly and the devil take rounding, then you have 42 gp of work at .17 gp per cubic foot, or 247.0588 cubic feet per week.)

If it wasn't for the fact that I'm valuing round numbers to make it easier on the running end, I would definitely go with 42 gp/week for cost and 250 cubic feet/week for progress (2.5 feet in length). Moving from 40 to 42 gp per week lets you get much closer to a reasonably round number for progress (40 gp/.17 comes out to about 235 cubic feet of progress).

Dwarf Mining Speed

Mine Type	GP Value per Load	Ore Mined per Week (Stone)	Metal Weight per Load	Expected Value per Week (50% quality)	Weekly Costs	Weekly Profits	Dwarf Profit Bonus	Non-Dwarf Owner
Copper	200	62.5	100	62.5	43.125	19.375	11.875	-68.125
Tin	200	125	100	125	46.25	78.75	23.75	-56.25
Lead	200	187.5	100	187.5	49.375	138.125	35.625	-44.375
Iron	200	250	100	250	52.5	197.5	47.5	-32.5
Silver	600	2.5	4	187.5	65	122.5	32.5	-47.5
Electrum	600	5	4	375	90	285	65	-15
Gold	600	7.5	4	562.5	115	447.5	97.5	17.5
Platinum	600	10	4	750	140	610	130	50

In these numbers, I'm giving dwarves a 25% productivity boost thanks to their sensitivity to earth and stone. Any other race or class with that custom power should get the same bonus. Every week of work by dwarves cuts out 300 cubic feet of rock (3 feet of length). 40 gp/week times 1.25 is 50 gp/week, divided by .17 gp per cubic foot gives us 294.etc cubic feet, which I round to 300. For those outside of their own clan who hire them, this costs 120 gp/week instead of 40 gp/week. The Non-Dwarf Owner column shows the profit difference between hiring humans to do the work and hiring dwarves to do the work. Remember that this assumes 50% quality;

the following table shows the minimum quality for various mines to make it worth hiring dwarves to work your vein for you. It is possible to make a profit with dwarves working a vein of lesser quality than shown on the table (usually about 2-3 quality lower), but you will make less profit that way than just hiring humans to do it. The table shows you the minimum quality necessary to make it actually worth hiring dwarves over humans. (Copper is N/A because there is no quality of copper for which it is worth it, though you will make a tiny profit at quality 10.)

Mine Type	Minimum Dwarf Quality
Copper	N/A
Tin	8
Lead	7
Iron	6
Silver	7
Electrum	6
Gold	5
Platinum	5

For those using nonstandard means to mine (maybe you have charmed umber hulks or a pair of *gnarly gloves of transmute stone to mud*), the following table shows you the conversion of 'cubic feet of stone gone through per week' to 'stone of ore gathered per week' by mine. Note that thanks to rounding errors, the dwarves do not obey this table; they have 50% more cubic footage of stone that they go through but only get 25% more ore. For game balance, it is important that they only get 25% more ore. If you have a problem with this rounding error occurring in your campaign, you can use the unrounded (or at least very lightly rounded) cubic footage numbers for human and dwarf progress of 235 and 295 cubic feet respectively. Alternately, you can simply say that dwarves are chopping out extra stone for future use as living quarters and the like.

Mine Type	Ore per Cubic Foot (Stone)
Copper	0.25
Tin	0.5
Lead	0.75
Iron	1
Silver	0.01
Electrum	0.02
Gold	0.03
Platinum	0.04

This table does include time spent sorting the ore and hauling rock away. If those things are not accounted for in the method being used, the Judge will need to apply a penalty based on it. Excavation, sorting, hauling, and shoring are the four tasks that need to be done; the table below shows what each costs per cubic foot. Thus, if you have umber hulks excavating for you, they can give you a very large boost to excavation (and to hauling as well), but will be largely unhelpful in shoring or sorting. An army of charmed umber hulks could give you a roughly 50% productivity boost. Of course, if you hired sufficient laborers to sort and shore at the speed they could excavate at, it could give you a much greater boost; a normal set of miners (master, journeymen, apprentices, 10 laborers) could perform the sorting and shoring tasks of roughly two miner-weeks when they are freed from the need to excavate and haul. Thus, in this umber hulk example, every miner team could sort out 400 cubic feet of stone to find the ore from it and provide sufficient bracing for four feet of tunnel per week. The following table shows the raw GP cost per cubic foot of each sub-task.

Task	Cost per Cubic Foot (GP)
Excavation	0.0625
Sorting	0.03125
Hauling	0.03125
Shoring	0.045
Total	0.17

In other words, a single laborer who does 1 sp of work per day can sort 3.2 cubic feet of stone for ore per day, or 96 cubic feet per month. If you want to round that to 100, I will not blame you one bit; it's what I would do, but I'm already writing down numbers like .03125, if you care enough to read that many numbers you might actually want to keep the real numbers. When sorting 100 cubic feet of ore from (let's say) a copper mine, he will find 25 stone of copper ore. (100 cubic feet of hard stone weighs somewhere in the general vicinity of 1500 stone; most of what is excavated is not metal-bearing.)