

[54] **SUB-SURFACE PARTICLE RECOVERY**
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[52] U.S. Cl..... **299/8, 37/76, 175/58, 175/107, 175/308**

[51] Int. Cl..... **E02d 1/00, E21c 41/14**

[58] Field of Search..... **299/8; 175/308-312, 58-60**

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[57] **ABSTRACT**

Metal particles, as for example gold, are recovered from sub-surface locations without requiring removal of the overburden. In particular, recovery of gold particles from cracks in underground or underwater bed-rock is enabled.

A process and apparatus is disclosed in which a hose is provided to lower a collector means to a sub-surface locality and deliver a stream of water. Means are also provided to rotate the collector to separate valuable material and recover same and cutter is included to cut into the formation at the locality.

28 Claims, 8 Drawing Figures

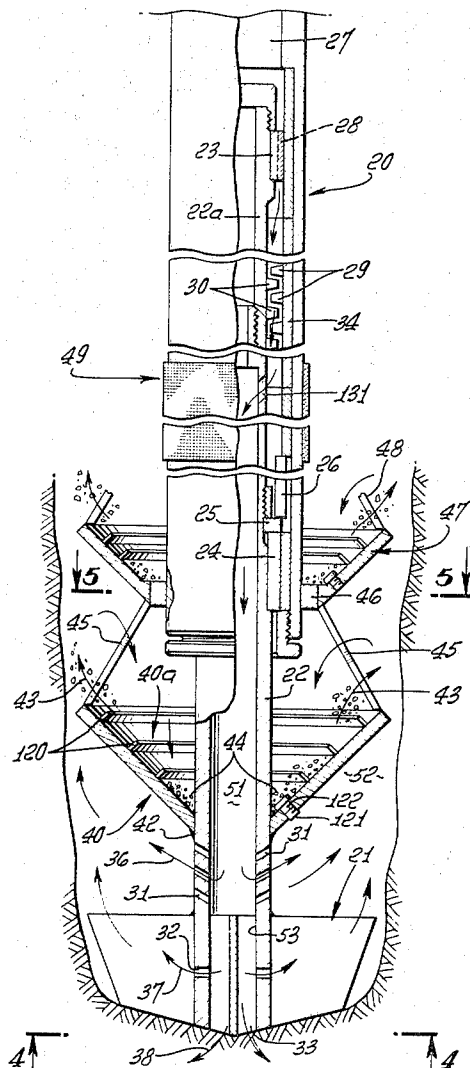


FIG. 1.

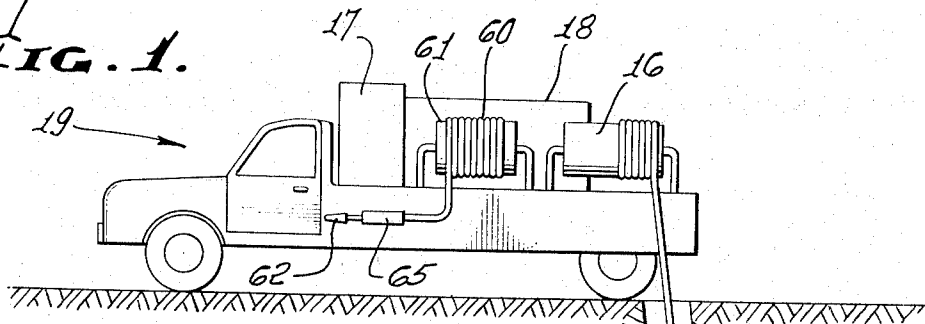


FIG. 6.

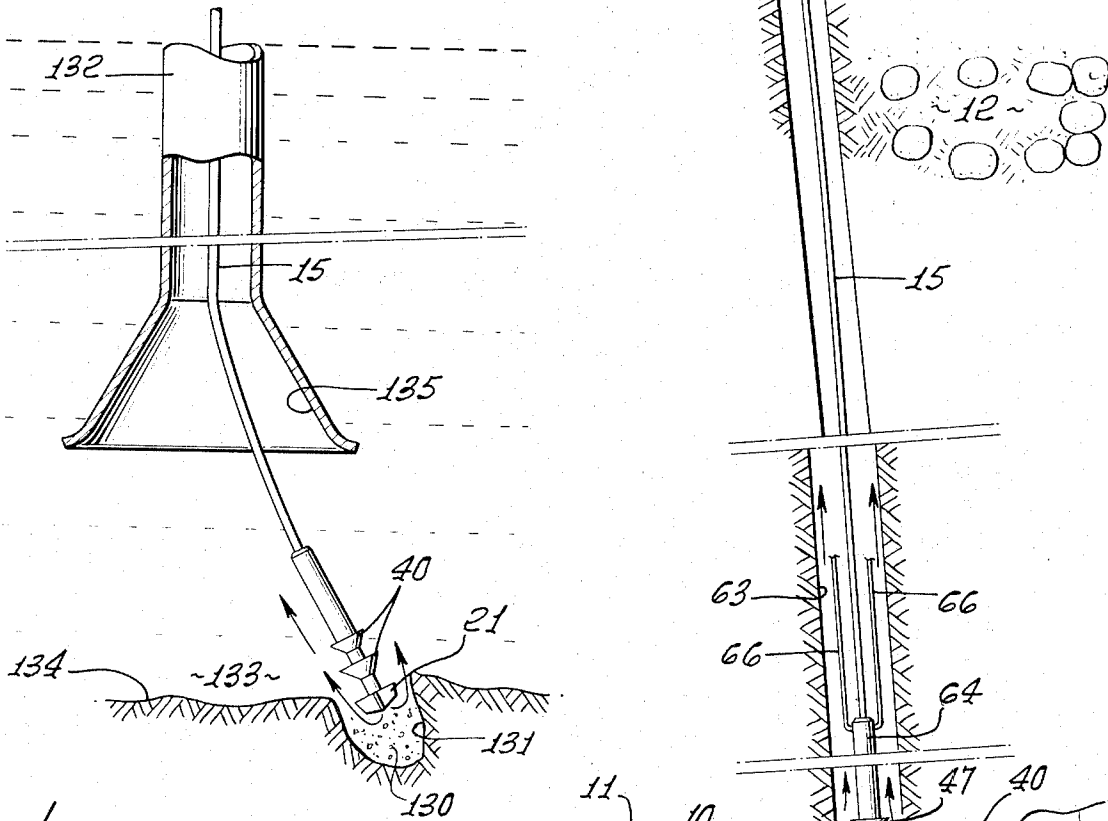


FIG. 8.

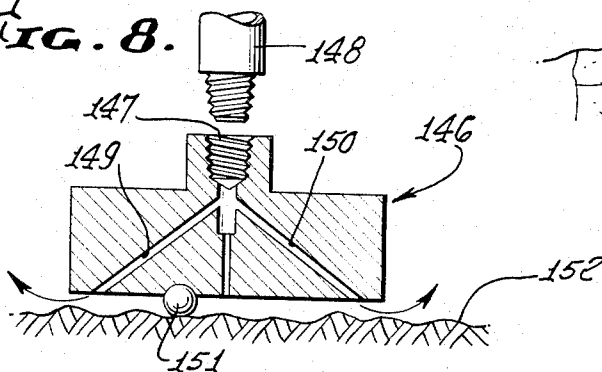


FIG. 3.

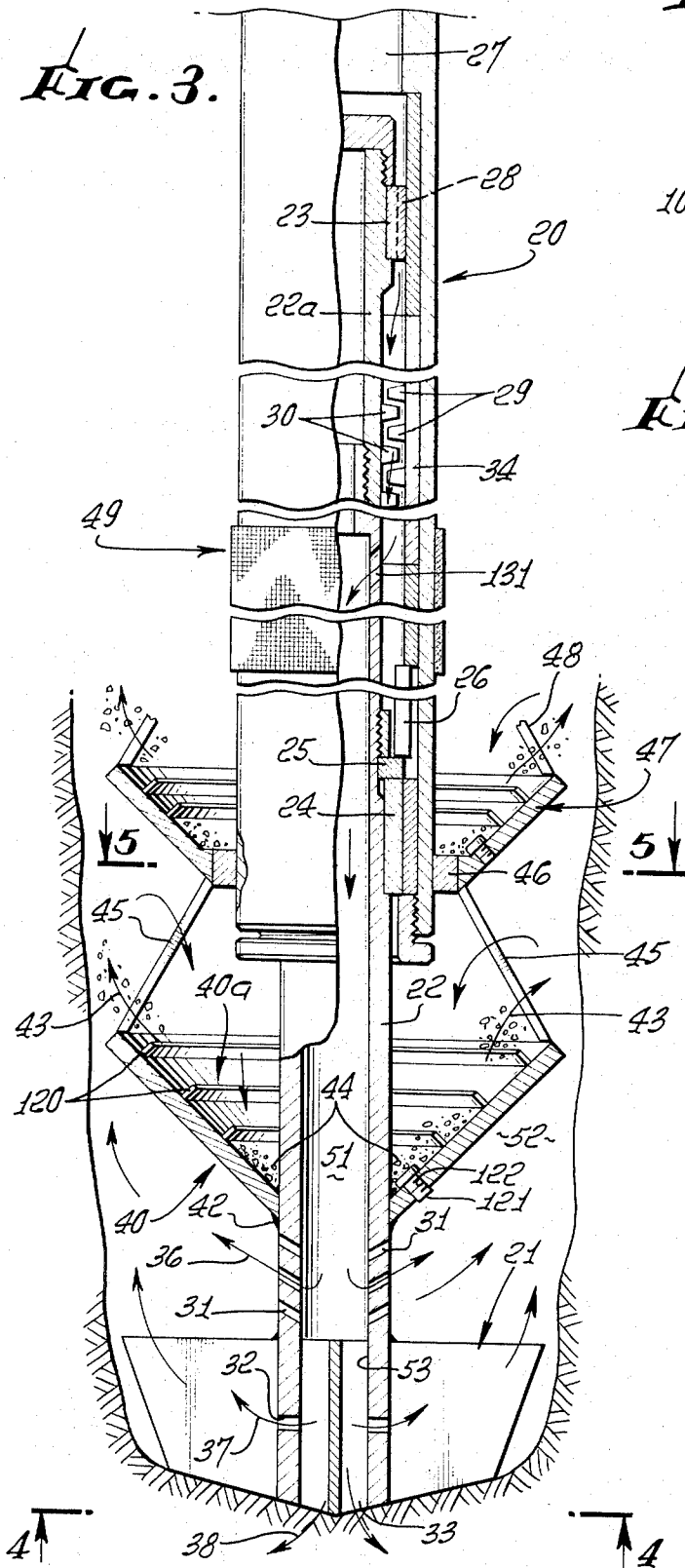


FIG. 2.

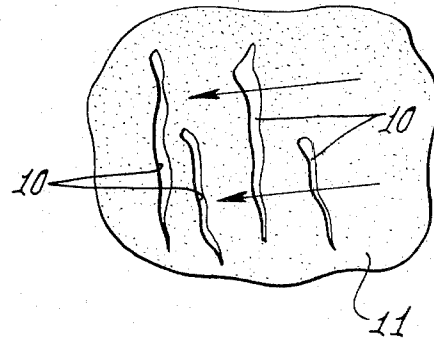


FIG. 4.

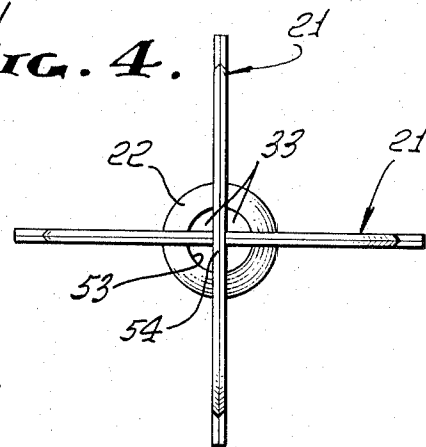


FIG. 5.

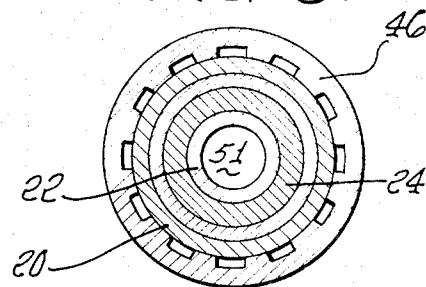
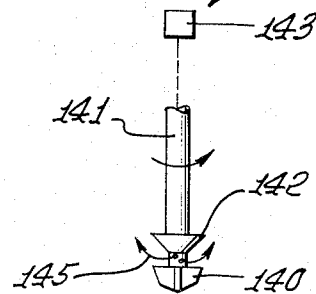


FIG. 7.



SUB-SURFACE PARTICLE RECOVERY

BACKGROUND OF THE INVENTION

This invention relates generally to the recovery of metallic particles at sub-surface localities, and more particularly concerns method and apparatus for effecting such recovery without removal of the overburden and without mining activity carried out by humans at underground levels.

Mining operations over large areas of the world have involved stripping the overburden off bedrock underlying streams where gold and/or other precious metal particles were concentrated. Typically, intermixed soil and rocks were re-deposited over the bedrock after dredging of the gold bearing layers; however, the bucket type dredging equipment that was conventionally employed could not reach much of the gold or metal particles, as for example larger particles that were trapped in cracks and crevices in the bedrock. Where ore recovery beneath the sea was conducted, ocean floor "sweeping operations" to recover loose particles and grannules did not contemplate recovery of inaccessible or trapped materials. No way was known, to my knowledge to accomplish recovery of such trapped precious metal particles in the simple manner as now afforded by the present invention. As to the latter, the invention is especially useful in that metal particle recovery may now be carried out beneath undisturbed land, without requiring stripping of the overburden off the bedrock.

SUMMARY OF THE INVENTION

It is a major object of the invention to provide solutions to the above problems, which will enable precious and other metal recovery at remote sub-surface locations, i.e. beneath the land or water body surface level.

Basically, and in its method aspect, the invention contemplates employment of an upwardly retrievable metal particle collector, and includes the steps of delivering water or other liquid in a pressurized stream to the sub-surface zone or locality (underground or at the bottom of a body of water, as for example a river, lake or ocean body); effecting displacement of earthen and metal particles at that locality in the water delivered thereto; locally collecting the displaced metal particles in the collector at that locality; and upwardly retrieving the collector. Both metallic and non-metallic formation particles are typically displaced upwardly in the released water stream to settle into one or more such collectors carried by a water delivery tube, and the collector or collectors may be rotated to centrifugally displace the non-metallic particles outwardly, leaving the metallic particles in the collector.

It is another object of the invention to effect displacement of the formation beneath the collector as by rotary drilling, a high speed turbine type drill being typically operated through utilization of the pressure of the water stream being delivered to the sub-surface locality. The drill may for example travel in and along inaccessible bedrock crevices wherein larger gold pieces and nuggets are trapped to comminute same and produce gold particles subject to water borne displacement and collection as described.

It is another object of the invention to support the drill and the collector or collectors on a water delivery

tube which may be lowered, guided and retrieved as desired, enabling progressive movement of the drill and collector into and through a series of sub-surface localities for gold collection and retrieval.

In its apparatus aspects, the invention concerns the provision of means to deliver water in a pressurized stream to the sub-surface locality for displacing particles at that locality, and a collector carried by the delivery means at a position to collect upwardly displaced particles at that locality and to be upwardly retrieved in response to upward displacement of the water delivery means. As will be seen, a rotary cutter is typically provided to be rotated below the collector as by a turbine rotor, the collector being carried to rotate with the cutter so as to centrifugally displace non-metallic particles from the collector, leaving metallic particles such as gold.

Additional objects include the provision of a water pressure delivery hose of a length to allow generally horizontal travel of the cutter and collector at bedrock location, enabling recovery of gold particles trapped in cracks and crevices; the provision of multiple rotary collectors in a vertically spaced series; the provision of a metallic particle adsorbing medium above the collector and carried by the water delivery line; and the provision of auxiliary means for hydraulically drilling a guide passage into the underground formation to initially receive and guide the rotating cutter.

These and other objects and advantages of the invention, as well as the details of an illustrative embodiment, will be more fully understood from the following description and drawings, in which:

DRAWING DESCRIPTION

FIG. 1 is an elevational showing of the invention, in use;

FIG. 2 is a plan view showing crevices in underground bedrock;

FIG. 3 is a vertical section showing details of one form of collector, cutter and drive apparatus;

FIG. 4 is a section on lines 4—4 of FIG. 3;

FIG. 5 is a section on lines 5—5 of FIG. 3;

FIG. 6 shows application of the invention to ocean floor metal particle recovery.

FIG. 7 is a vertical elevation showing other apparatus incorporating the invention; and

FIG. 8 is a modified form of the apparatus.

DETAILED DESCRIPTION

Referring first to FIGS. 1 and 2, the invention makes possible to recovery of metal particles, as for example gold and other precious metals, from sub-surface localities such as cracks and crevices 10 in bedrock 11, all without removal of the overburden 12. Such cracks or crevices typically exist under present or past streams, and may contain larger gold particles including nuggets which dredging buckets cannot or could not retrieve. The bedrock may lie between 50 and 150 feet below the surface 13; however, the invention is applicable to other areas, where bedrock may be much deeper.

In accordance with the invention, means is provided, as for example tubing 15, to deliver water in a pressurized stream to an underground locality, as at 10, for displacing metallic particles 14 at that locality in the delivered water; and, a collector is carried by such means at a position to collect the displaced particles, and to be upwardly retrievable in response to upward displace-

ment of the tubing. The latter may be flexible so as to be wound on a drum 16 at the surface, the drum being rotatable to extend the tubing and to retract same wherein desired. A source of pressurized water is indicated at 17 and may include a suitable pump the outlet of which is connected at 18 with the tubing. These elements may be suitably carried, as for example by a vehicle 19. During operation over a body of water, a floating vessel may be employed, the tubing then extending downwardly in the water to the floor where the pressurized water stream is delivered for displacing metal particles to be collected.

Referring to FIGS. 3-5, the lower extent of the water delivery means may include a metallic housing 20 supporting a rotary cutter 21. The cutter is carried by a tubular shaft 22 projecting below the housing and supported therein for rotation as by suitable bearing sleeves 23 and 24. Axial loading is transmitted between the shaft and housing as by thrust bearing elements 25 and 26. Pressurized water flows downwardly from the tubing into the housing passage 27, then downwardly through ports 28 in the bearing sleeve 23, then downwardly past stator vanes 29 and rotor vanes 30 to enter the shaft via ports 31, and then downwardly toward the cutter to exit from the shaft as at ports 31, 32 and 33.

The stator vanes 29 carried by a sleeve section 34 associated with the housing direct the water into the rotor vanes carried by the shaft upper section 22a, and at an impingement angle causing the rotor vanes and the shaft to rotate at a relatively high velocity, for example between 700 and 1,500 RPM to develop between 60 and 200 horsepower delivered to the cutter or bit.

The lower portion of the shaft with ports 31-33 may be considered as a nozzle, from which water exits as indicated by arrows 36-38 to displace particles loosened by the cutter, or adjacent the nozzle, as to entrain them to flow upwardly about the collector indicated at 40. Such particles may typically include earth and rock material as well as metallic particles such as gold and other precious or valuable metals displaced in and from the cracks and crevices previously mentioned. The collector is shown as supported directly above the cutter, and has frusto-conical shape tapering downwardly toward the cutter, whereby the upward streams of water and entrained particles flow outwardly and upwardly about the collector at increased velocity, and then inwardly toward the housing above the collector at reduced velocity. As a consequence, the particulate material settles into the collector interior at 40a; however, since the cutter is operatively connected with the rapidly rotating structure (as at connection 42 to the shaft 22), the lighter material including earth and small rock particles are centrifugally thrown outwardly as indicated by arrows 43, leaving the heavier metallic particles, including gold, retained at 44 within the collector, the angularity of the collector being such as to achieve this result. Spider arms 45 connect the collector with a suitable guide ring 46 centering on the cylindrical housing 20 as shown. Additional collectors of progressively reduced outer diameters may be provided in vertical series, one of these being indicated at 47 attached to ring 46 to be rotated by collector 40. Spider arms 48 connect the collector 47 with another guide ring, not shown, centering on housing 20. All the collectors operate in the same manner, recovering heavy metallic particles from the rising water streams. If desired, con-

centric or spiral riffles may be incorporated in the collectors as at 120, to aid retention of metal particles.

A metallic particle adsorbing medium 49 may be carried by the housing portion of the tubing to extend above the collector or collectors for adsorbing or catching very small lightweight metal particles remaining in the water streams rising above the collectors and adjacent the housing. Such material may for example consist of natural wool or similar material forming small interstices in which particles become trapped.

Referring again to ports 31, they may be directed upwardly as shown to pass pressurized water in jets from the interior 51 of the shaft to the region 52 directly below the collector 40. Ports 32 may be directed radially to jet water between the four, or other suitable number, blades of the cutter; and ports 33 may be directed downwardly to deliver water under pressure to the formation for hydraulically displacing same. Merely as illustrative, ports 33 may be formed between the bore 53 of the shaft and the inner extents 54 of the cutters as best seen in FIG. 4.

Referring back to FIG. 1, means may be provided for hydraulically drilling a guide passage in the formation 12 to initially receive and guide the cutter and collector downwardly toward the metal particle retrieval locality, as for example is exemplified by the crevice 10. Such means may include a conduit 60 on a reel 61, and having a terminal nozzle 62 to which water under pressure is delivered (as from unit 17) to hydraulically bore into the formation. The thus formed guide passage is indicated at 63. Weight, such as drill collars, may be added or connected to the tubing 15 and to the conduit 60, as at 64 and 65 respectively, to urge and direct the cutter 21 and nozzle 62 downwardly. Further, guide wires may be connected to such weights as indicated at 66 and may be manipulated at the surface to direct the angularity from vertical of the downward progress and the lateral bodily displacement of the cutter at the locality 10 as by directional force exertion on the tubing. For example, the crevices over an extended region of the bedrock may successively penetrated and traversed by the cutter, through controlled manipulation of the guide lines.

At regular intervals, the collector or collectors may be upwardly retrieved as by upward withdrawal of the tubing 15, to remove collected metal particles. Water flowing back upwardly to the surface may be allowed to percolate into the soil, or may be collected and re-used.

Referring again to FIG. 3, threaded plugs 121 are shown connected into the collectors to close threaded bores 122, proximate the lowermost interiors of the collectors. Such plugs may be removed after upward recovery of the apparatus to the surface, to enable connection of water lines to the bores for flushing out the segregated metal particles.

FIG. 6 shows an application of the invention to recovery of metal particles 130 trapped in an ocean (or other water body) floor crevice 131. A metallic tubular guide 132 may be employed to downwardly pass the apparatus (including rotary cutter 21 and collectors 40 on flexible tubing 15) to a selected zone 133 proximate the ocean floor 134. A downwardly opening bell 135 guides the apparatus into the tube 132 upon upward retrieval, and it allows lateral movement or travel of the apparatus at the ocean floor for cutting into the trapped particles 130 lengthwise of the crevice.

The invention also contemplates that the tubing 15 may be rigid, as may take the form of a string of metal drill pipe or tubing as used in oil well operations. FIG. 7 shows a cutter or bit 140 at the lower end of a rigid tube 141, with a conical collector 142 also carried by the tube. The latter may be rotated by suitable means 143, as for example a power swivel (which may operate at a subsurface level) or a rotary table at the surface. Hydraulic fluid may be supplied to the tube to exit near the bit and under the collector, as shown by arrows 145. The means 143 may alternatively comprise an electric motor near the bit and collector location, for rotating these elements, as via suitable structure represented at 141.

In FIG. 8, a bit 146 is attachable at 147 to a rotary tube 148 which may be turbine driven, as described above. Ducts 149 and 150 in the bit conduct hydraulic fluid to the exterior to entrain cuttings and elevate them to a collector carried by tube 148, but not shown. A projection such as a hardened ball 151 eccentrically carried by one of the four blades of the bit, at the underside thereof, is engageable with the uneven bedrock surface 152 to cause the turbine driven bit to vibrate and jump up and down while rotating at high speeds. This motion causes a faster settling of the gold in the collectors or pans.

I claim:

1. The method of recovering metallic particles in a formation at a sub-surface locality and employing an upwardly retrievable cutter and collector, that includes

- a. delivering water in a pressurized stream to said locality,
- b. operating the cutter to cut into the formation proximate the collector to loosen said particles and effecting displacement of particles at said locality in the water delivered thereto,
- c. locally collecting said displaced particles in the collector at said locality, and rotating the collector to centrifugally displace non-metallic material from the collector, and
- d. upwardly retrieving the collector.

2. The method of claim 1 including the step of simultaneously rotating the cutter at said locality.

3. The method of claim 2 wherein said cutter is rotated in a crevice in the formation at said locality.

4. The method of claim 2 wherein said delivery step includes releasing the pressurized water stream downwardly into the formation directly below the collector to displace the formation therebelow enabling progressive lowering of the collector therein.

5. The method of claim 1 wherein the particles are trapped in rock crevices, and wherein said water delivery step includes locally releasing the pressurized water stream into said crevices.

6. The method of claim 1 wherein an elongated tube is employed to deliver the pressurized stream to a nozzle below the collector at said locality, and including the step of exerting force on the tube to effect generally lateral movement of the nozzle and collector progressively into a series of sub-surface localities.

7. The method of claim 1 wherein the particles consist of gold.

8. The method of recovering metallic particles at a sub-surface locality and employing an upwardly retrievable collector, that includes

a. delivering water in a pressurized stream to said locality,

b. effecting water borne displacement of both metallic and non-metallic particles at said locality in the water delivered thereto, and from beneath said collector to a region directly above the collector for collection therein,

c. locally collecting said displaced particles in the collector at said locality, and rotating the collector to centrifugally displace non-metallic particles from the collector, and

d. upwardly retrieving the collector.

9. The method of recovering metallic particles at a sub-surface locality and employing an upwardly retrievable collector, that includes

a. delivering water in a pressurized stream to said locality,

b. effecting simultaneous displacement of both the sub-surface formation and particles at said locality in the water delivered thereto, said displacement of the formation including the step of operating a rotary turbine driven drill to drill the formation at said locality, said operating step including utilizing the pressure of the water stream being delivered to said locality to operate the turbine to rotate the drill directly below the collector,

c. locally collecting said displaced particles in the collector at said locality, and rotating the collector to centrifugally displace non-metallic particles from the collector, and

d. upwardly retrieving the collector.

10. The method of claim 9 including the preliminary step of hydraulically drilling a downward passage in the formation, and thereafter introducing said rotary turbine type drill into the formation via said passage for subsequent drilling, as defined.

11. The method of claim 9 wherein said drilling is carried out to comminute gold nuggets in situ, thereby to produce said particles.

12. The method of recovering metallic particles in a formation at a sub-surface locality and employing an upwardly retrievable cutter and collector, that includes

a. delivering water in a pressurized stream to said locality,

b. operating the cutter to cut into the formation proximate the collector to loosen said particles and effecting displacement of particles at said locality in the water delivered thereto,

c. locally collecting said displaced particles in the collector of said locality,

d. there being an elongated tube delivering the pressurized stream to a nozzle below the collector at said locality, and including the steps of exerting force on the tube to effect generally lateral movement of the nozzle and collector progressively into a series of sub-surface localities, and supporting metallic particle adsorbing medium on the tube above the collector for absorbing lightweight particles entrained in upward water flow released from the nozzle.

13. In apparatus for recovering metallic particles in a formation at a sub-surface locality,

a. means to deliver water in a pressurized stream to said locality for displacing particles at said locality in the water delivered thereto,

- b. a collector carried by said means at a position to collect the displaced particles at said locality, and to be upwardly retrievable in response to upward displacement of said means,
 - c. a cutter carried by said means and located below the collector for rotation to cut into said formation and loosen the particles for said displacement, and
 - d. other means to effect rotation of the collector at speeds characterized in that non-metallic formation particles are thrown outwardly from the collector while metallic particles are retained in the collector.
14. The apparatus of claim 13 wherein said means includes tubing extending to said locality and supporting the collector, and including retrieval means at the surface and connected with the tubing to retrieve same and thereby retrieve said collector.
15. In apparatus for recovering metallic particles at a sub-surface locality,
- a. means to deliver water in a pressurized stream to said locality for displacing particles at said locality in the water delivered thereto,
 - b. a collector carried by said means at a position to collect the displaced particles at said locality, and to be upwardly retrievable in response to upward displacement of said means, and
 - c. including a rotary cutter operable to drill into the sub-surface formation, a turbine rotor connected in rotary driving relation with the cutter, and tubing supporting the turbine rotor to deliver said pressurized water stream thereto to rotate the turbine, the turbine rotor also connected to rotate the collector at speeds characterized in that non-metallic formation particles are thrown outwardly from the collector while metallic particles are retained in the collector.
16. The apparatus of claim 15 wherein the collector is supported directly above the cutter for rotation therewith, thereby to centrifugally displace non-metallic particles from the collector.
17. The apparatus of claim 16 wherein the collector has frusto-conical shape and tapers downwardly toward the cutter, the collector being upwardly open about the tubing, which extends axially therethrough, to receive particles tending to settle as the particles are displaced upwardly about and above the collector in the water stream delivered to said locality.
18. The apparatus of claim 16 wherein the tubing includes a flexible hose of a length to allow generally horizontal travel of the cutter at the sub-surface location.
19. The apparatus of claim 15 including means for hydraulically drilling a guide passage in the formation to initially receive the cutter.
20. The apparatus of claim 15 including a tubular metallic guide loosely extending about said tubing to pass the tubing, cutter and collector vertically in a body of water.
21. In apparatus for recovering metallic particles at a sub-surface locality,
- a. means to deliver water in a pressurized stream to said locality for displacing particles at said locality in the water delivered thereto,
 - b. a collector carried by said means at a position to collect the displaced particles at said locality, and

- to be upwardly retrievable in response to upward displacement of said means, and
 - c. there being at least one additional collector carried by said means above said first mentioned collector, said collectors being upwardly open and tapering downwardly, and there being a fluid motor responsive to water pressure delivery thereto to effect rotation of the collectors, and
 - d. other means to effect rotation of the collectors at speeds characterized in that non-metallic particles are thrown outwardly from the collectors while metallic particles are retained in the collectors.
22. In apparatus for recovering metallic particles at a sub-surface locality,
- a. means to deliver water in a pressurized stream to said locality for displacing particles at said locality in the water delivered thereto,
 - b. a collector carried by said means at a position to collect the displaced particles at said locality, and to be upwardly retrievable in response to upward displacement of said means,
 - c. a rotary cutter carried by said means and operable to drill into the sub-surface formation, a turbine rotor connected in rotary driving relation with the cutter, and tubing supporting the turbine rotor to deliver said pressurized water stream thereto to rotate the turbine,
 - d. the collector being supported directly above the cutter for rotation therewith, thereby to centrifugally displace non-metallic particles from the collector, and
 - e. a metallic particle absorbing medium carried by the tubing to extend above the collector for absorbing lightweight particles entrained in upward water flow.
23. In apparatus for recovering metallic particles at a sub-surface locality,
- a. means to deliver water in a pressurized stream to said locality for displacing particles at said locality in the water delivered thereto,
 - b. a collector carried by said means at a position to collect the displaced particles at said locality, and to be upwardly retrievable in response to upward displacement of said means, and
 - c. the collector being generally frusto-conical and containing a normally plugged port to pass flush-out fluid, and raffle means being located within the collector upwardly open interior to promote metal particle retention within the lower interior of the collector.
24. In combination,
- a. a rotary bit adapted to cut into a sub-surface formation,
 - b. an upwardly open rotary collector located at a higher elevation than the bit to receive and collect formation particles displaced upwardly from the bit, and
 - c. means to support the bit and collector for simultaneous vertical movement in the sub-surface formation and to rotate the bit and collector at speeds characterized in that non-metallic formation particles are thrown outwardly from the collector while metallic particles are retained in the collector.
25. The combination of claim 24 wherein said means to rotate the bit and collector comprises a rotary table.

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26. The combination of claim 24 wherein said means to rotate the bit and collector comprises a power swivel.

27. The apparatus of claim 24 including a downward projection carried by the bit in eccentric relation to the bit axis of rotation, to be rotated against the uneven

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upper face of sub-surface bedrock, thereby to move the bit up and down during rotation thereof.

28. The apparatus of claim 24 wherein said means to rotate the bit and collector comprises an electric motor proximate the bit and collector.

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