Examples of Various Kinds of DRILLING RIGS

J. David Rogers

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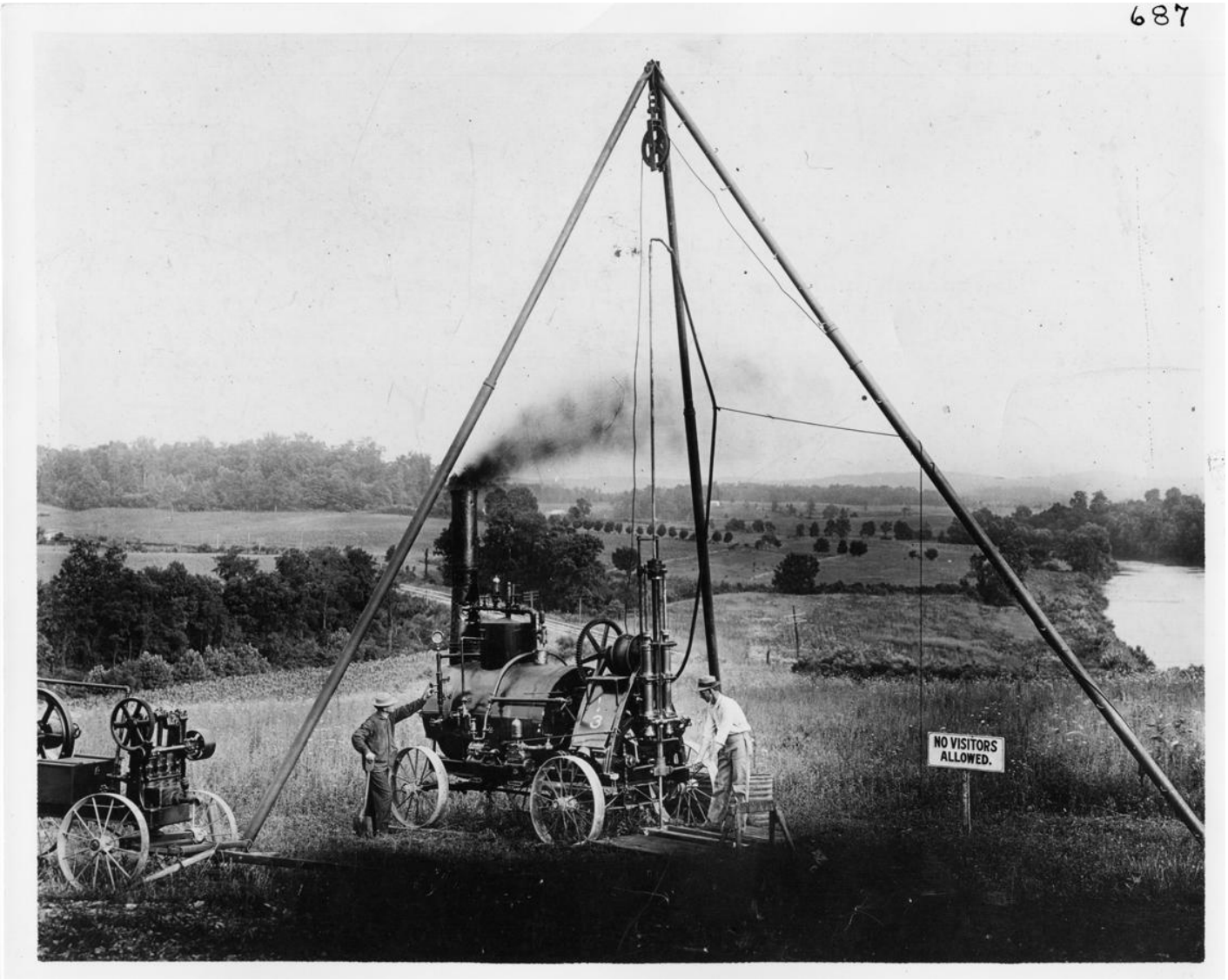

- **One of the earliest diamond drilling machines is the steam-powered rig shown here in 1908, recovering cores for assessment of shallow coal deposits in Illinois.** ***From Illinois State Geological Survey***

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- From about 1900, shallow “dry borings” for geotechnical exploration utilized a 3-man crew with a simple A-frame, such as that shown here, along with a gas powered engine. This could be set up and broken down by hand, in confined spaces.

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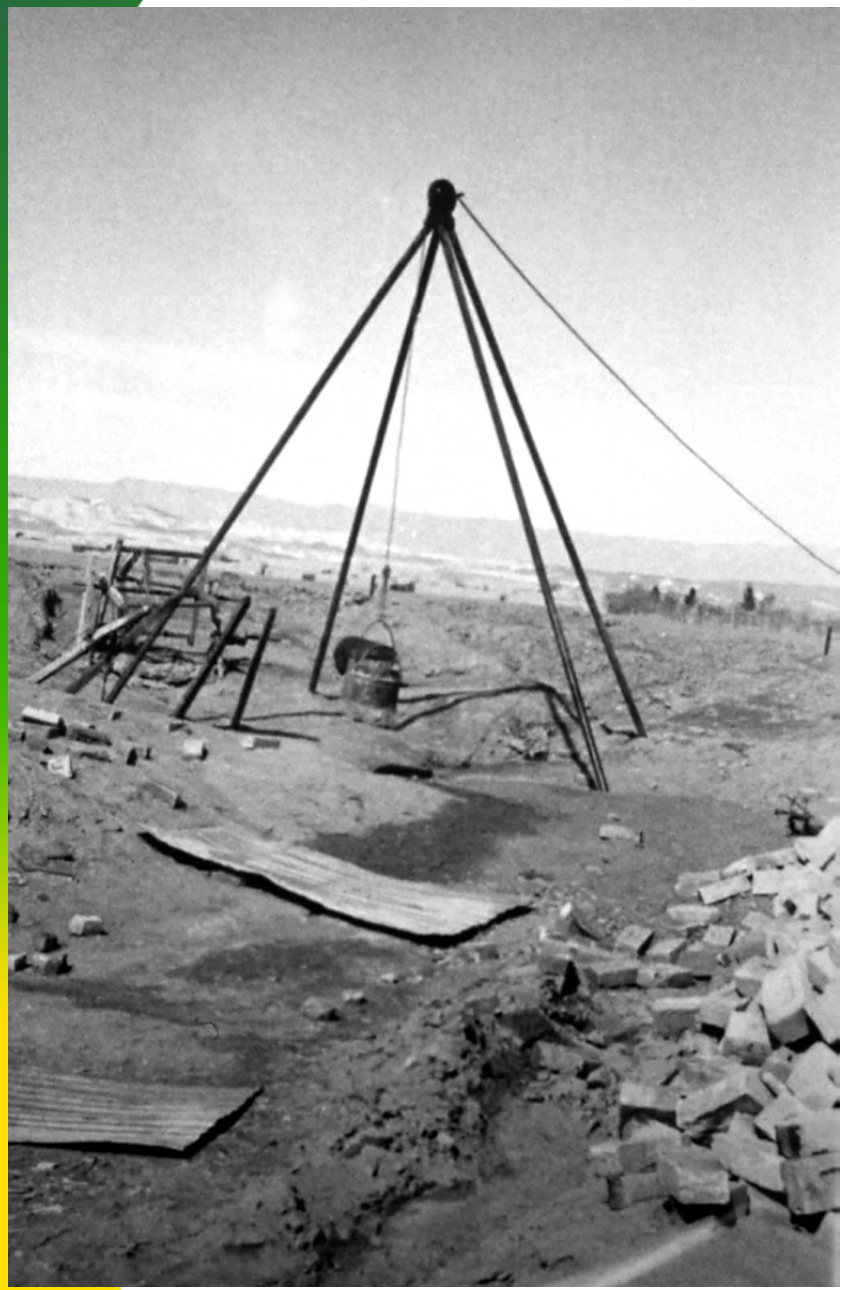

A-frame rigs

- A-frame rigs are still utilized world wide for drilling exploratory borings and advancing large diameter caissons, as the example shown here.
- This is an early example of a large diameter “bucket auger” excavation for a dam site in Montana

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Old SPT Sampler

- The original SPT sampler was developed by the Gow Division of the Raymond Concrete Pile Co. in the late 1920s
- It used a 140 lb weight dropping 30 inches, using a rope drag line wrapped around a cat head, shown here
- Blowcounts are measured in the field as the sampler is driven into the ground

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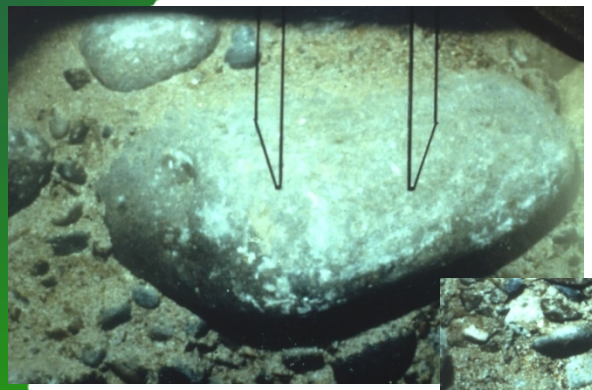

Damage and Disturbance

- **Sampler shoes** and **heads** become increasingly damaged and deformed when used in granular materials, like cobbles and rock
- This disturbance invalidates comparative measurements, such as N_{spt} or $(N_1)_{60}$

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Smear and selvage

- Drive samples should be assumed to be disturbed
- Their perimeter is often covered with a selvage of smeared material that may not be representative of the actual horizon being sampled
- This selvage of gooey material should be lightly scrapped to ascertain what the sample interval actually recovered

- Samples of ***cohesionless materials***, such as coarse sand (shown here), may not be recoverable as neat cylinders of coherent material; esp. if sampling below the water table.

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Advantages of the SPT Test

- Usually the most economical method of testing
- Provides physical sample for soil classification
- Long service life of equipment
- Vast SPT database
- Numerous empirical correlations with SPT
- Other methods available to supplement when more refinement justified (e.g. liquefaction analyses)

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Most Common Errors when Using SPT test

- Damaged drive shoes
- Variation in hammer fall
- Effect of overburden pressure (if not corrected)
- Driving a stone ahead of the sampler
- Hollow stem auger “quick condition” in saturated cohesionless soils
- Careless or inexperienced drilling crew

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HOLLOW FLIGHT AUGERS

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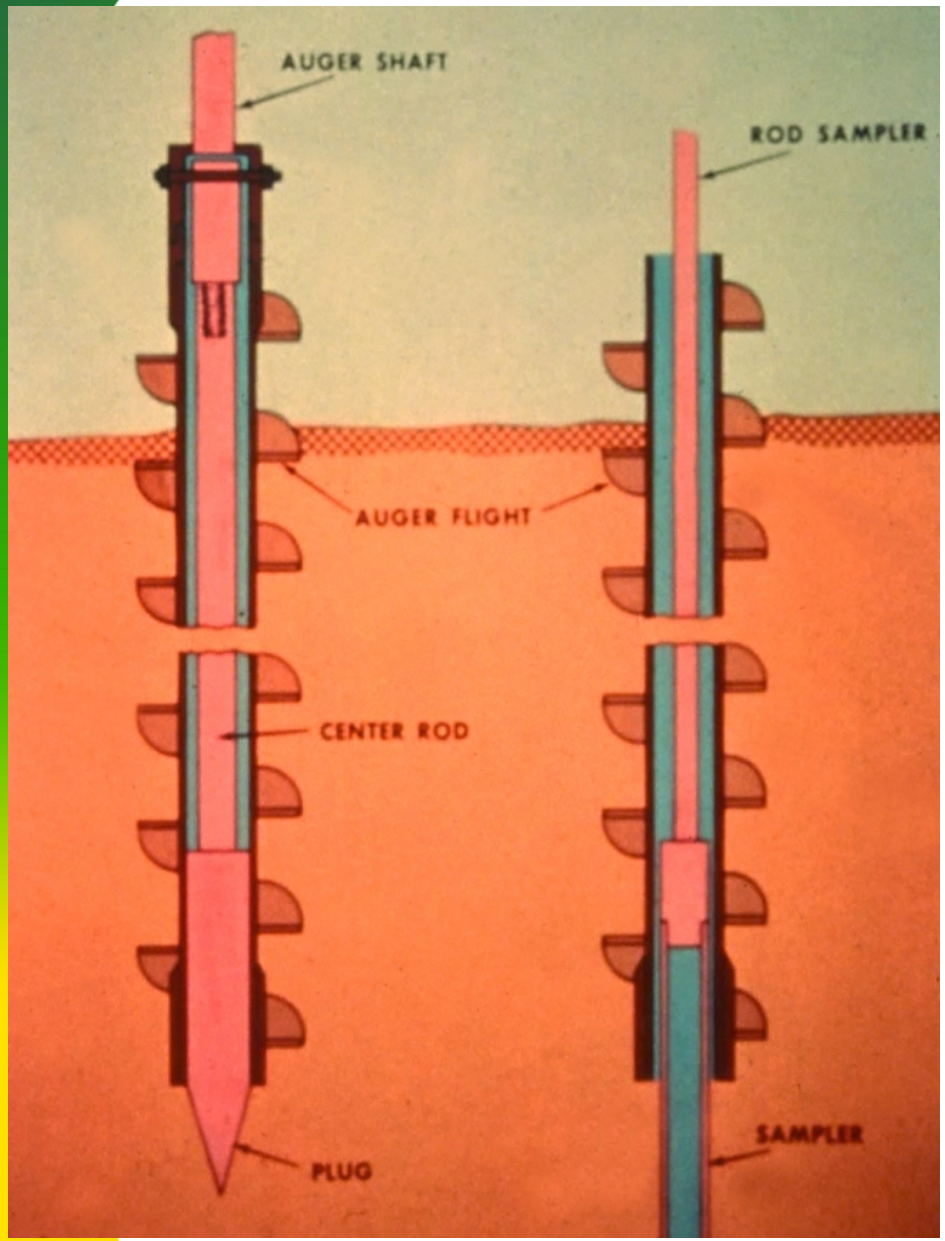

Sampling through hollow flight augers

- Hollow flight augers are commonly employed in high groundwater conditions
- Drive samplers can be inserted inside the hollow cylinders
- Note sample disturbance caused by penetration of the plug

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Hollow flight augers

- **Hollow flight augers** can be used with most conventional drill rigs. The stems cost more per lineal foot, but the hole can be advanced between sampling rounds without having to withdraw the drill stems

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Hollow Flight Augers

- Hollow flight augers began appearing in the late 1920s for drilling geotechnical borings in running sands and low cohesion materials
- This shows a conventional SPT sampling barrel being set inside hollow flight augers.

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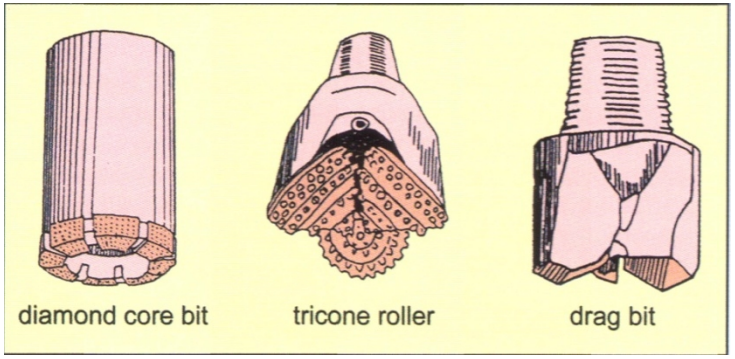
MUD ROTARY DRILLING



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- **Mud rotary drilling rigs** are typically used for deeper applications, such as holes more than 50 or 100 feet deep, below the water table

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Rotary Wells Usually Drilled with Tricone Bits

- The tricone bit was developed by Hughes Tool Co. in 1933 to drill deeper oil wells. It has been refined many times since then. It uses three distinctive rotating cutting heads, with interior flushing of the drill cuttings by the drilling mud

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Drilling Mud Circulation Tanks

- Mud rotary drilling employs a dense drilling fluid under its own hydrostatic pressure to support the walls of an open borehole
- The drilling fluid is usually comprised of ***bentonite***, but some drillers will use soap or a variety of other agents, depending on local experience

Rotary Rigs

- Rotary rigs with their masts extended. A water truck usually accompanies the rig, to provide the drilling fluid.

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Large Mud Rotary Drill Rig

- Most deep water wells are drilled with larger mud rotary rigs, like this Gardner-Denver 1500 series rig with a 40 ft mast.
- The biggest headache is loss of circulation, most common in limestone or adjacent to broken rock along faults

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DIFFICULT CONDITIONS FOR SUBSURFACE SAMPLING

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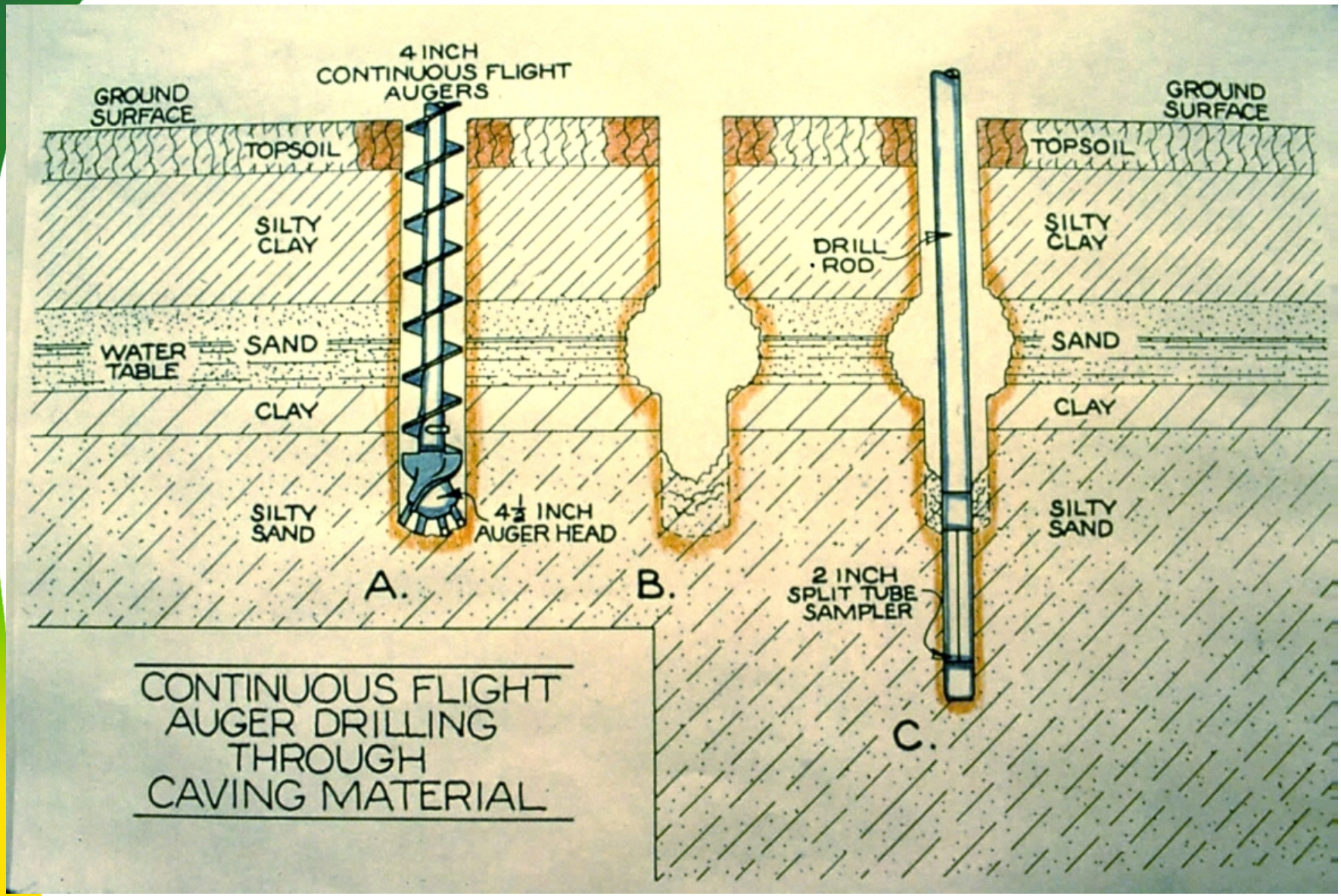

- **Common causes of caving in a shallow borehole**

Sticky Clayey Silt

- One of the most challenging conditions to drill and sample in are sticky clayey silts, such as those pictured here; which stick to the auger flights

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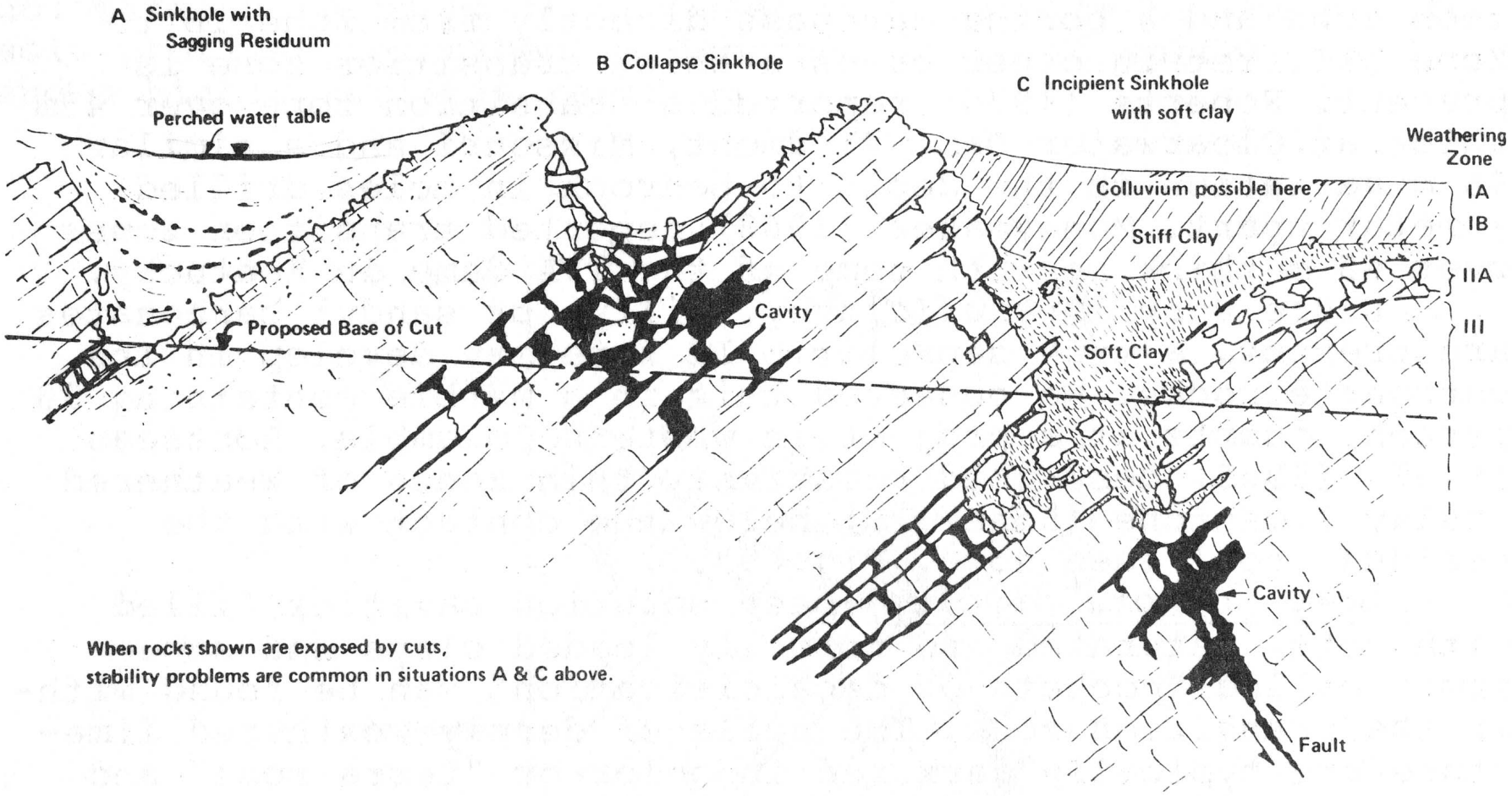

- Loss of ***drilling fluid circulation*** is common in weathered **carbonate rocks** with open cavities. ***Clay-filled cavities*** can be also problematic where they contain rock '***floaters***'

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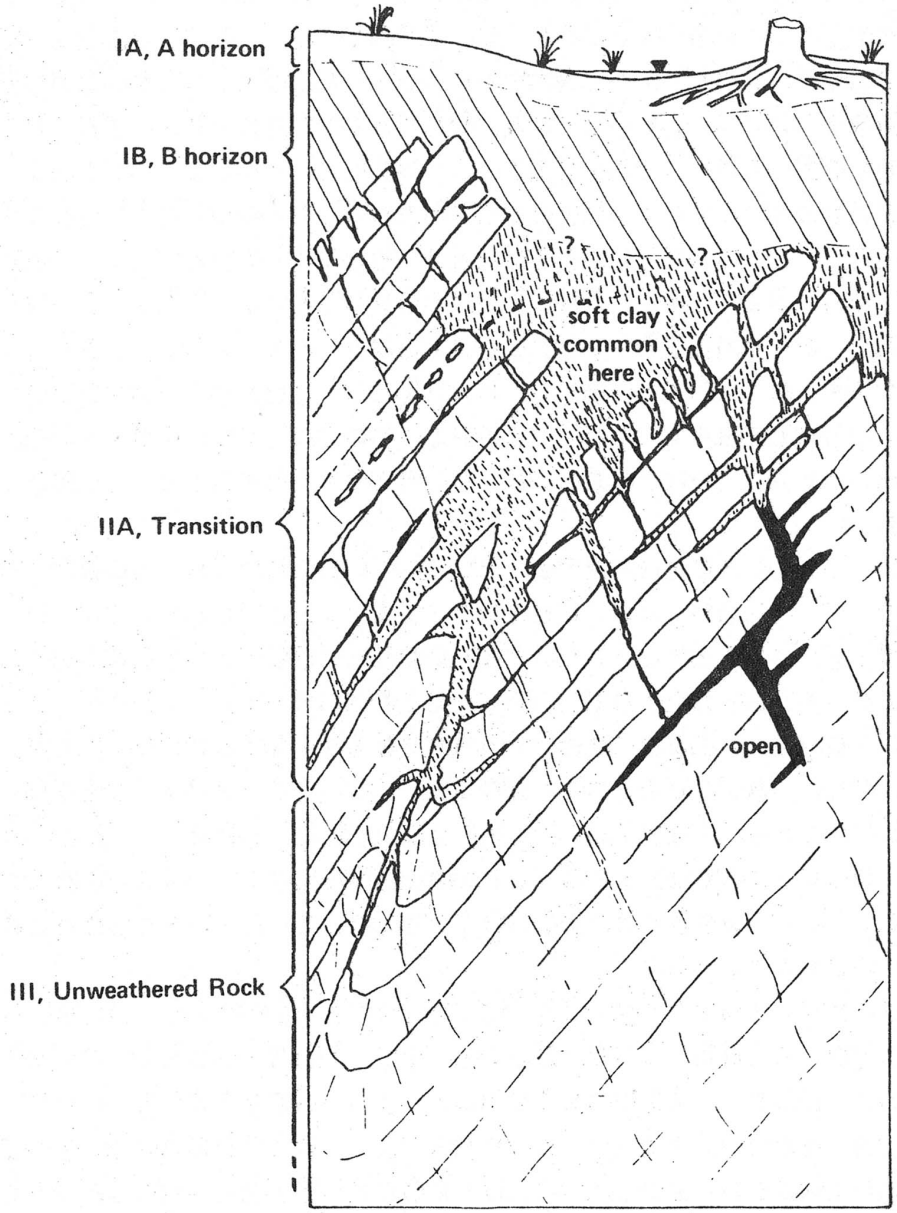


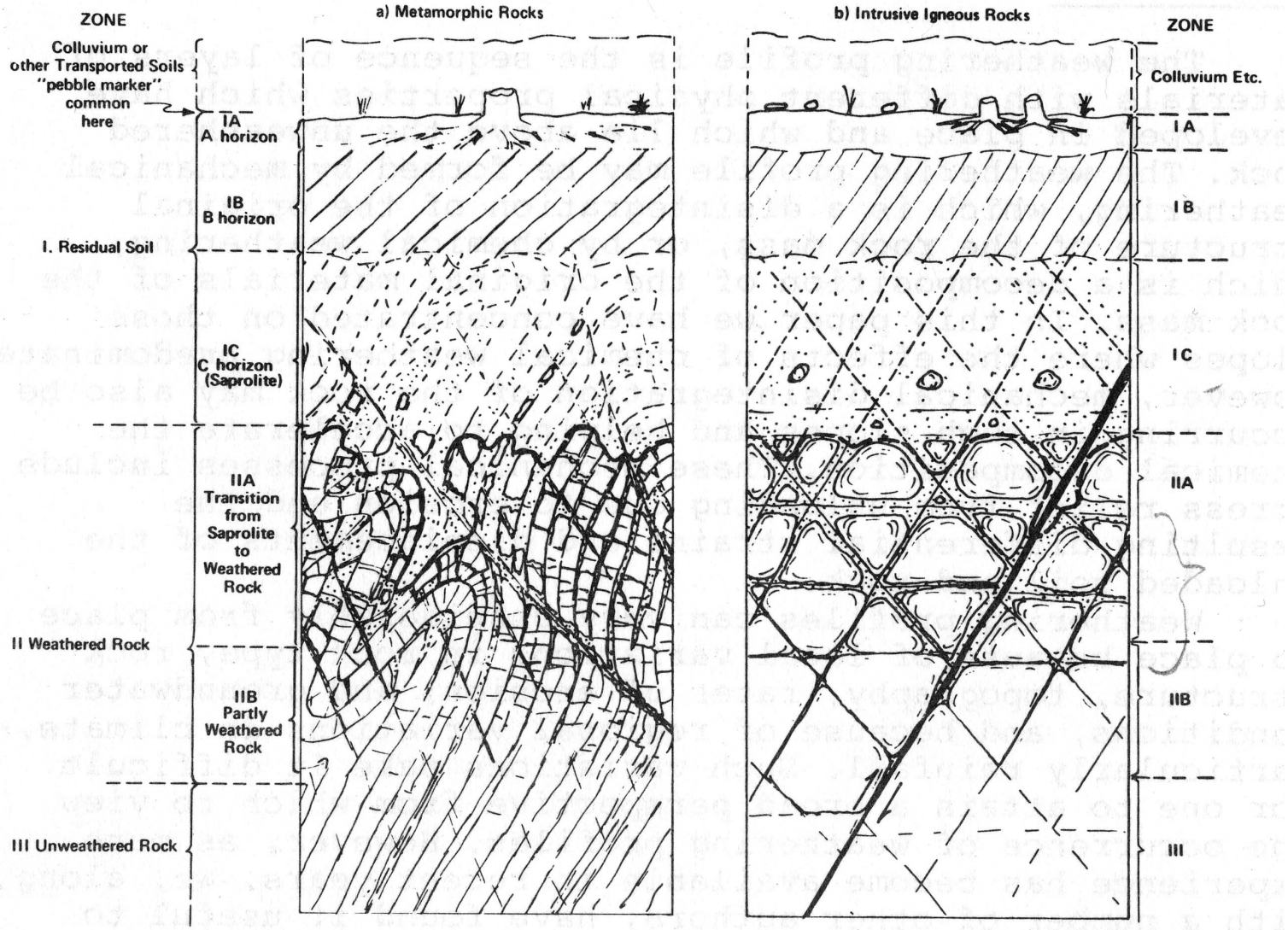
NOTES:

1) Very impure (sandy or silty) carbonates may develope a saprolite, IC zone.

2) A partly weathered chalky limestone, IIB zone is sometimes present.

Residuum

- **Residual soils** profiles can be highly undulatory and anisotropic, as portrayed here
- Beware of deeply incised weathering zones along faults, shears, contacts, fold axes, or lithologic horizons



- **Typical weathering profiles in metamorphic and igneous rocks. *Floating clasts* are always problematic in developing reliable cross sections.**

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DEALING WITH DIFFICULT SITE ACCESS CONDITIONS

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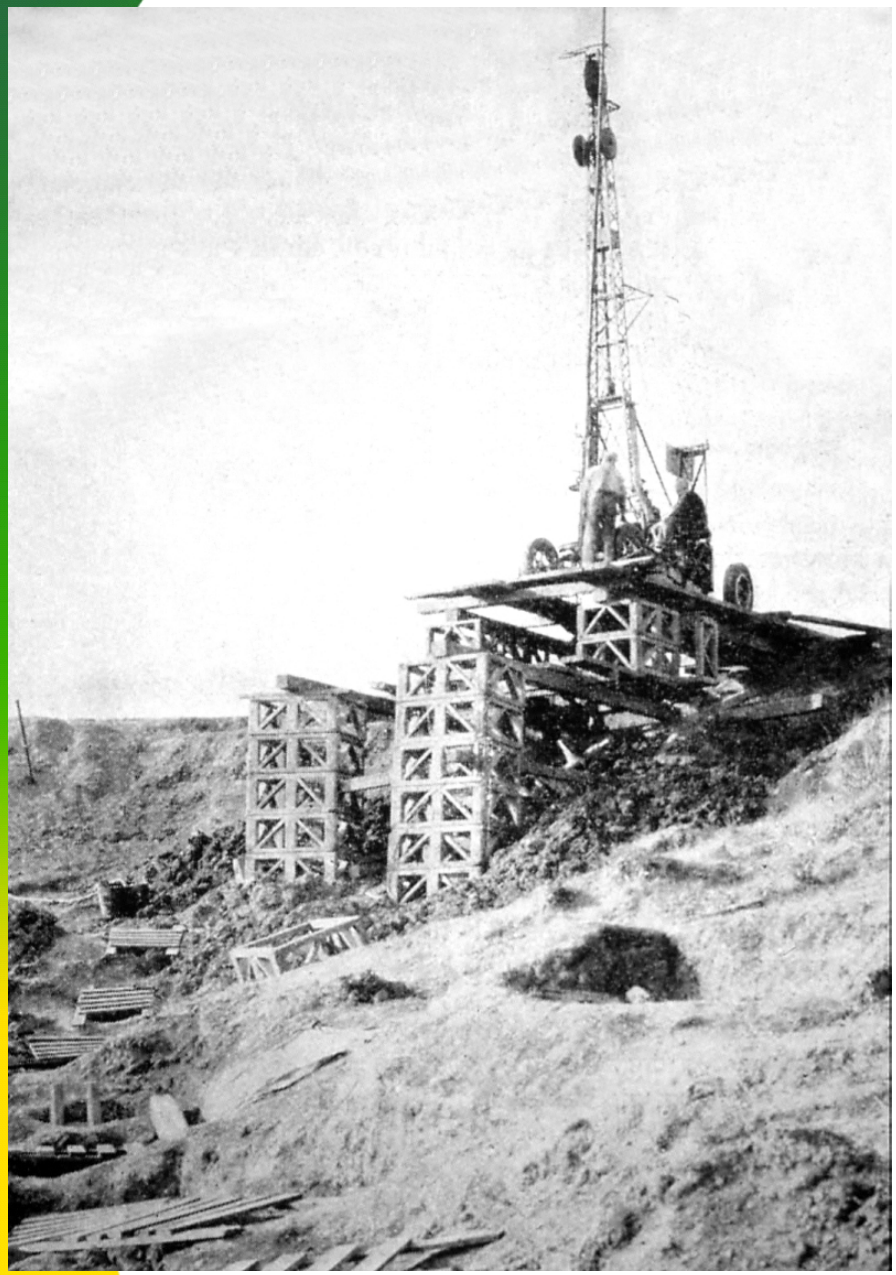

CRIBBING STANDS

- In the old days, temporary wood or steel cribbing was erected to support a drilling platform, or ‘pad’, as shown here along Pacific Coast Highway in Pacific Palisades, California in 1940.

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(Photograph courtesy U.S. Bureau Reclamation, Boulder City, Nevada and Glen Lasson.)

FIGURE 11. Hazards of dam site exploration met by unusual drill set-up. Looking downstream into inner gorge of the Little Colorado River at the Coconino dam site near Cameron, Arizona.

Drilling Platforms

- This shows a temporary drilling platform set up across the narrow gorge of the Little Colorado River, near Cameron, Arizona in the early 1940s
- Such platforms are removed after drilling

Truck-mounted drill rigs

- Generally used on semi-level ground, if easy site access
- Quick set-up
- Rate of advance depends on height of mast & drill strings
- Large normal force can be employed (see left below)

- **Some lighter 4WD equipped drill rigs can be employed on uneven ground and in hillside situations, using the hydraulic leveling rams.**

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Tracked Rigs

- A number of manufacturers offer tracked rigs of varying size
- These can be extremely useful when working on sift or sloping ground

Tracked Rigs

Smaller tracked rigs can be operated remotely, using radio controls

Largest production tracked rig is the CME 850, shown at left

- **‘Swamp hog’ all terrain vehicles use oversize floatation tires inflated ~ 4 psi tire pressure to allow access on soft, mucky ground**

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- **Portable ‘skid rig’ placed on a fat-bottom barge or ‘John Boat’, in lower Mississippi Delta area. Biggest problem is anchoring the craft to resist drilling-induced torque.**

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Portable Minuteman Rigs

- Foremost Mobile produces 265 lbs portable drill known as ‘Minuteman” rigs
- Uses a 60 lb hammer

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- **This view shows a custom remote drilling rig powered by remote-source offsite hydraulics. It is working on a 30 degree slope 500+ feet above the nearest bench.**

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Helicopter Assist

- Under conditions of extreme remoteness, helicopters can sometimes provide vertical lift of lighter *skid rigs*
- This shows drilling pad set up for exploring path of the Tetsuo Harano Tunnels on Interstate H-3 through the Koolau Range in Oahu, Hawaii.

ENGINEERING GEOLOGIC LOGGING OF EXPLORATORY TRENCHES

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- **Exploratory trenches are an inexpensive method to get a 3D evaluation of soil conditions and shallow geologic structure. Usually used in rural, undeveloped areas.**

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- Trenches are generally excavated by backhoe. They must be shored if > 5.5 ft deep in most states. Mechanically compacting backfill can be expensive.

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- **Trenches have the potential to reveal complex subsurface structural relationships, such as geologic contacts, faults, previously disturbed ground, and anomalies reveled in geophysical surveys, like sinkholes.**

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Mapping of Pedogenic horizons – exposed horizons can be delicately examined and logged in open excavations. This occasionally allows for radiometric dating.

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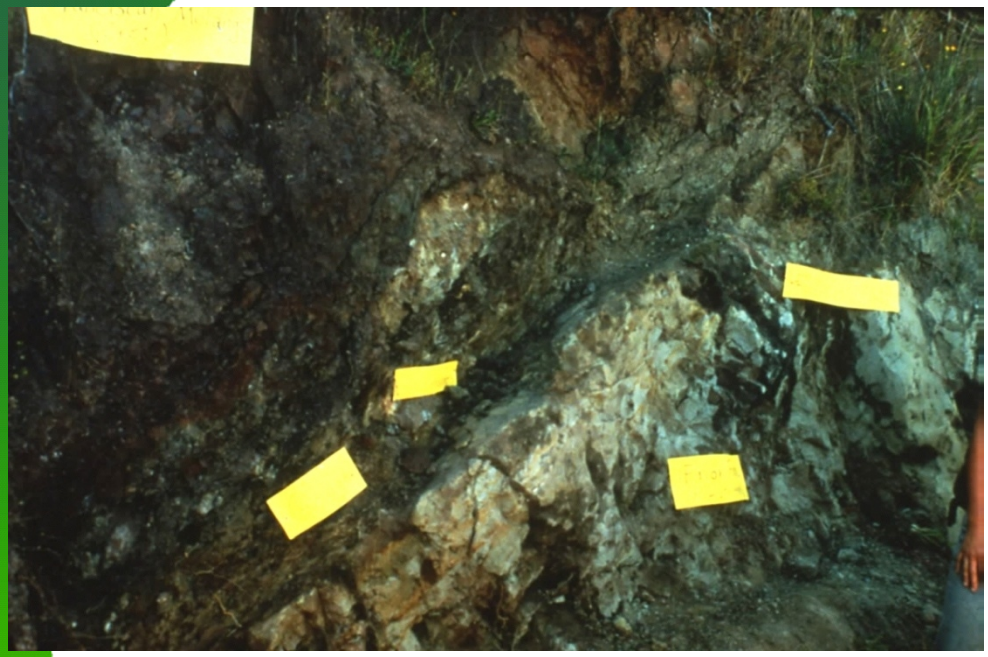

Strategic Sample Recovery and Insitu testing

- Low strength horizons can be identfied and recovered for laboratory testing; or
- ***Insitu shear strength tests*** can be carried out in the field

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LARGE DIAMETER EXCAVATIONS FOR PERSONAL ENGINEERING GEOLOGIC INSPECTION

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- **Bucket augers** are 24 to 36-in diameter holes drilled for downhole geologic inspection. They are usually advanced by large truck-mounted drill rigs.

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- **Bucket auger holes are generally excavated using standard flights with drag or chisel bits, as shown at right. Tracked mounted rigs are sometimes needed in hillside situations.**

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- **A geologist is lowered down the hole with hardhat, radio headset, protective overhead covering, and methane and carbon dioxide meters and an emergency supply of oxygen.**

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- **The collar zone of the large diameter holes is temporarily cased to prevent fall-in of broken ground near the ground surface**

Teamwork

- A two person team logs the hole, using two-way radio communication
- In this manner a large amount of data can be recorded in a short period of time, including structural information such as strike and dip, orientation of joints, and shear planes, etc.

Specialty Rigs

- Some operators have built their own rigs, which allow them to work on steep or constricted work sites
- Most of these 'remote rigs' employ hydraulic fluid, which can be transmitted to the drill rig by hoses laid out from pumps towed behind vehicles, as much as 200 feet away.

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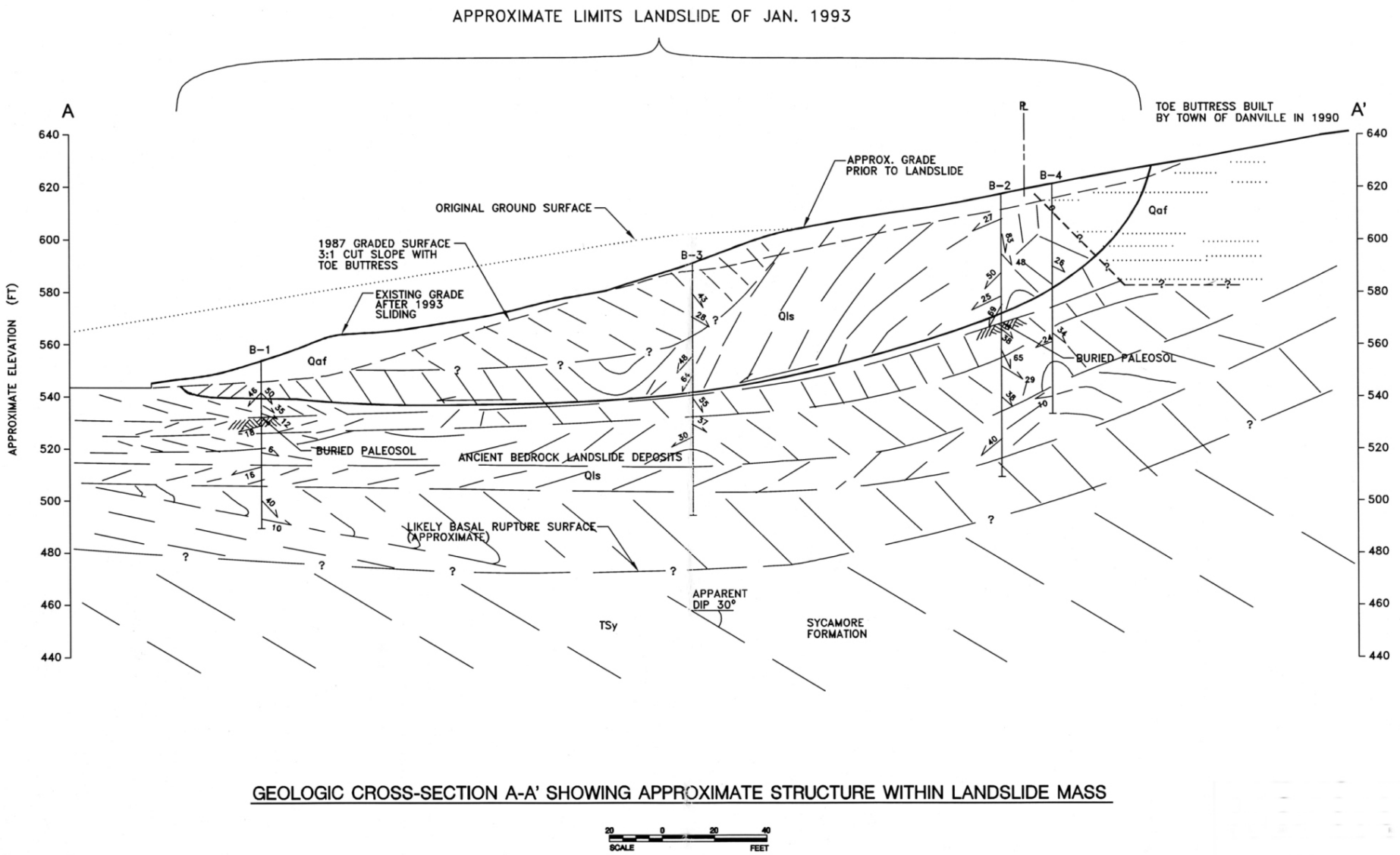

GEOLOGIC CROSS-SECTION A-A' SHOWING APPROXIMATE STRUCTURE WITHIN LANDSLIDE MASS

- **Geologic cross section through an active landslide complex derived from bucket auger information.**

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- **Mike Scullin, RG, CEG, CPG (1932-1995), the father of grading codes**

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