

SALTWORK TRAINING - SALINE GEOSYSTEMS



“SCIENTIFIC KNOWLEDGE IS IN PERPETUAL EVOLUTION; IT FINDS IT-
SELF CHANGED FROM ONE DAY TO THE NEXT”

JEAN PIAGET

WHY?

Most geologists and geophysicists working in oil and gas provinces, or base and precious metals systems, wherever salt or related brines are present, know that salt has played a role in forming the commodity of interest.

Want to know how and why this relatively small group of sediments, their brines and their metamorphic products are so significant to so many aspects across the applied geo-industries? We share this knowledge through our on-line and in-house training modules.

for more info please visit : www.saltworkconsultants.com

SALTWORK TRAINING

WHAT YOU WILL GET

The catalogue outlines the various training modules we offer across all applied aspects of evaporite studies. Our course structure is modular so you, or your training coordinator, can construct a training program that meets your particular needs.

The recommended online program length is three to five days, made up of two to three days of the “understandings” module (1000 code #'s), followed by a more specialized one to three days. Our advanced modules are suitable for specific interests;

- 1) Oil & gas (2100 code #'s)
- 2) Potash (2200 code #'s)
- 3) Resources (23-2600's codes)

We can also integrate training with the specific problem sets that your staff are working with, including core, wireline, assay, seismic and other data sets. Introductory aspects of training by a hands-on use of these data sets are also possible (e.g. an introduction to wireline interpretation, followed by wireline interpretation in carbonates).

Talk to us and we will design a program for you.

enquiries@saltworkconsultants.com





OUR PROGRAM

A COMPREHENSIVE COVERAGE OF SALINE GEOSYSTEMS

Understandings

- What is an evaporite?
- Brine evolution
- Ancient basins
- Evaporite that was

Non-potash salines

- Lithium brines
- Sodic Salts (soda-ash & salt cake)
- Borates

Oil and Gas

- Salt tectonics
- Saline reservoirs
- Source rocks

Metals and salts

- Statabound copper
- Pb and Zn
- High temperature saline ores

Geology of Potash

- Brine extraction
- Geology
- Potential problems

Related topics

- Solution Mining
- Meta-evaporites
- Dealing with saline geohazards

UNDERSTANDINGS





WHAT IS AN EVAPORITE?

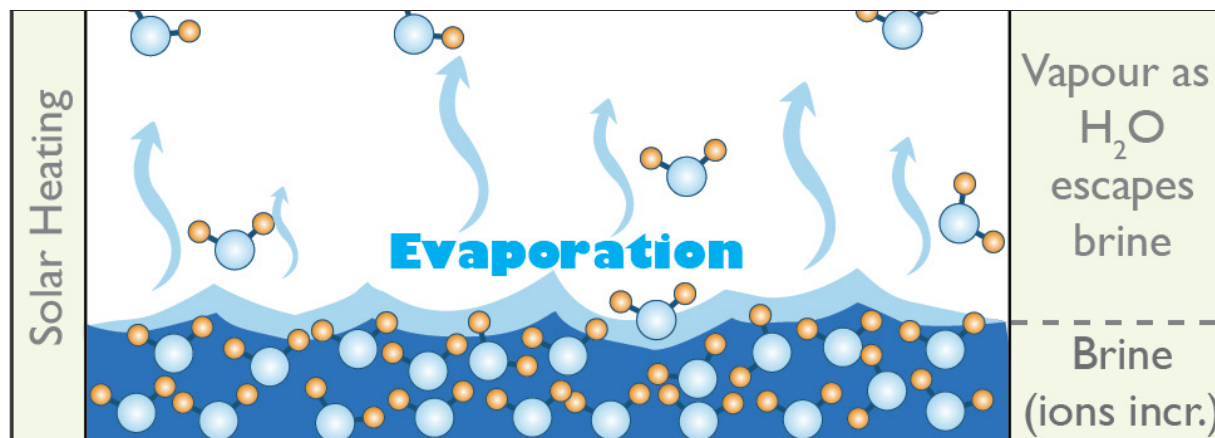
Evaporite beds are deposited and then altered, with characteristic textures indicating the original hydrological setting and ocean chemistry, as well as the various diagenetic fluids it was exposed to during burial, re-equilibration and uplift.

Topics: Evaporation vs. cryogenesis; Depositional textures; Diagenetic textures; Gypsum and anhydrite; Saline clay authigenesis.



Course No. 1000

Course 1000's overview modules (2 days) are recommended as a common base to all courses



BRINE EVOLUTION

Every evaporite sequence mineralogy and daughter product is controlled by brine evolution pathways. This evolution is preserved in brine chemistries and typical isotopic signatures (S, O, C, Cl).

Topics: Marine, nonmarine & climate; Inclusion chemistries; Isotopic signatures; Surface & nearsurface brine; Basinal & metamorphic brine



Course No. 1025



ANCIENT BASINS

In evaporite geosystems, the present offers a limited sampling of broader evaporite associations in the past. This reflects the limited climatic and tectonic spectrum seen in today's evaporites. Past systems were more significant.

Topics: Eustasy, greenhouse, icehouse; Continental basins; Marine-margin platform basins; Ancient basinwide systems; Tectonic controls; Basin evolution across time



Course No. 1050



EVAPORITE THAT WAS

Although largely unrecognized, there are widespread indicators of evaporites in successions where thick sequences of salt have long since dissolved in cross-flushing basinal waters.

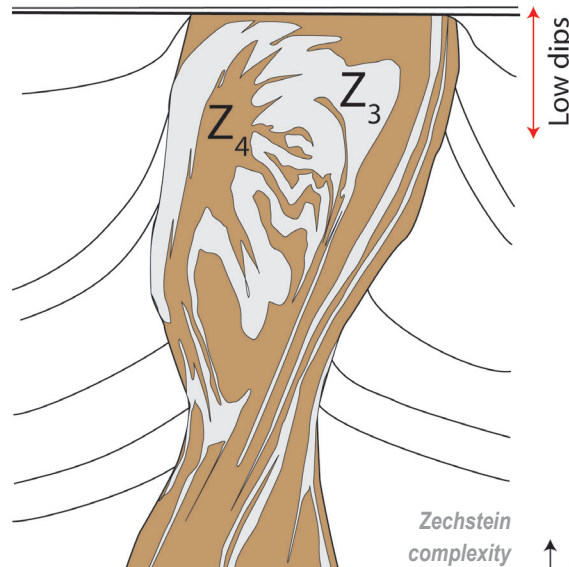
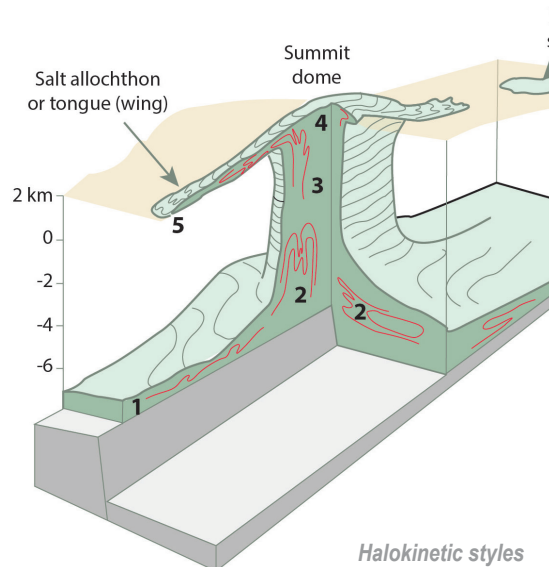
Topics: How and where salts dissolve; Saline karst, present & past; Breccias, which are salty? Nodules & pseudomorphs; Indicators of fluid pathways



Course No. 1075

OIL AND GAS





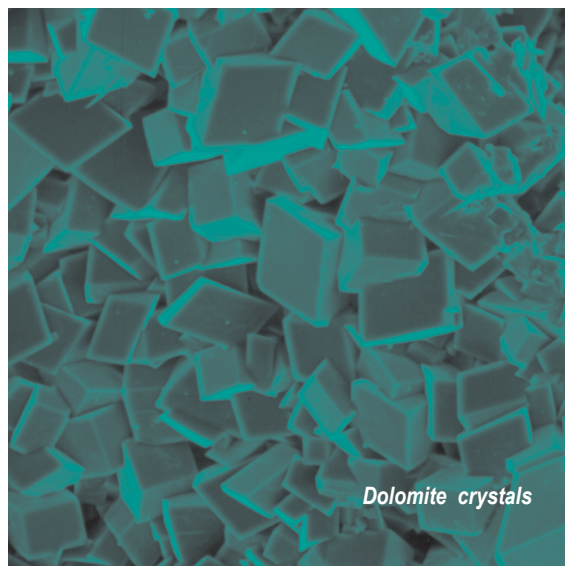
SALT TECTONICS

Many of the world's oil and gas fields occur in halokinetic-ly-influenced structures across many of the world's salt basins. The module gives a predictive understanding of salt and how it controls local and regional salt tectonics, reservoir sedimentation and diagenesis.

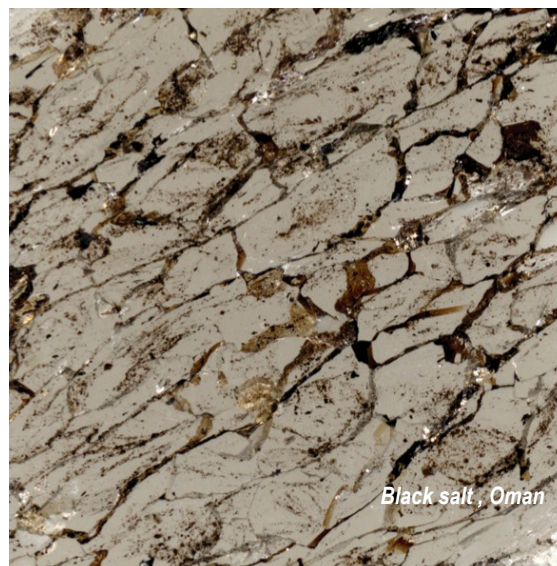
Topics: Salt tectonics & basin-scales; Predictive salt models; Circum-salt diagenesis; Reservoir patterns and their prediction



Course No. 2125



Dolomite crystals



Black salt, Oman

SALINE RESERVOIRS

Many giant and supergiant oil and gas fields are associated with salt. With carbonate reservoirs, the proportion is more than 50%. This is especially so in the Middle East and the circum-Atlantic Aptian. Worldwide, all supergiant fields in thrust belts are evaporite sealed.

Topics: Physics of salt seals; Bedded associations; Bedded seal examples; Halokinetic examples; Saline dolomite examples.



Course No. 2150



SOURCE ROCKS

Oil in carbonate reservoirs, sealed by evaporite salts, may have been sourced in earlier less saline, but still related, evaporitic (mesohaline) conditions. There halotolerants tend to flourish in mesohaline waters. subject to "feast and famine" so making source rocks

Topics: Organic geochemistry of halotolerants and halophiles; Indicative biomarkers; The four main ancient evaporitic source rock systems; Time limits of the modern.



Course No. 2175







Cane Creek, Utah, USA



Wendover, Utah

BRINE EXTRACTION (MOP VS SOP)

Brine extraction defines Quaternary production of muriate of potash and sulfate of potash. Depending on brine inflow proportions, and the (evaporitic versus cryogenic), the product is carnallite (Dead Sea or Wendover) or sulfate of potash (Lop Nur and Great Salt Lake).

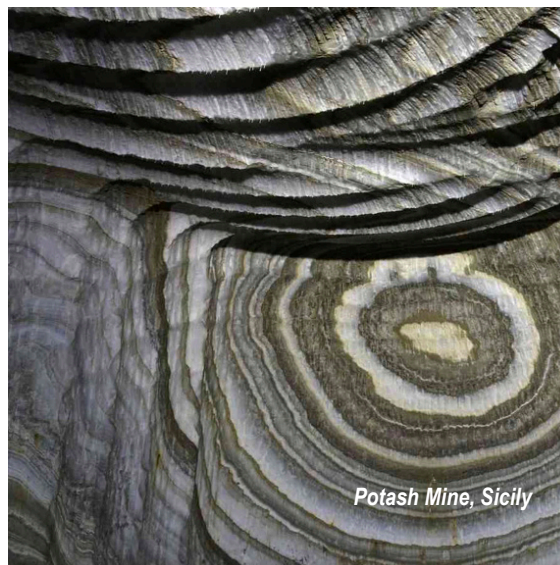
Topics: Marine vs. nonmarine deposits; Extraction techniques; Tectonics, climate & brines; Controls on muriate of potash (MOP) vs sulphate of potash (SOP)



Course No. 2225



Sylvinite



Potash Mine, Sicily

GEOLOGY OF POTASH

The greater part of the world's potash is conventionally mined from ancient salt beds or diapiric salt masses. Geological characterisation of all the world's potash deposits shows early through late diagenesis is a significant control on ore quality.

Topics: Potash deposits; Diagenesis and ore; World potash basins in a tectonic and eustatic context; Exploration criteria using the $MgSO_4$ dichotomy and time



Course No. 2250



POSSIBLE HAZARDS

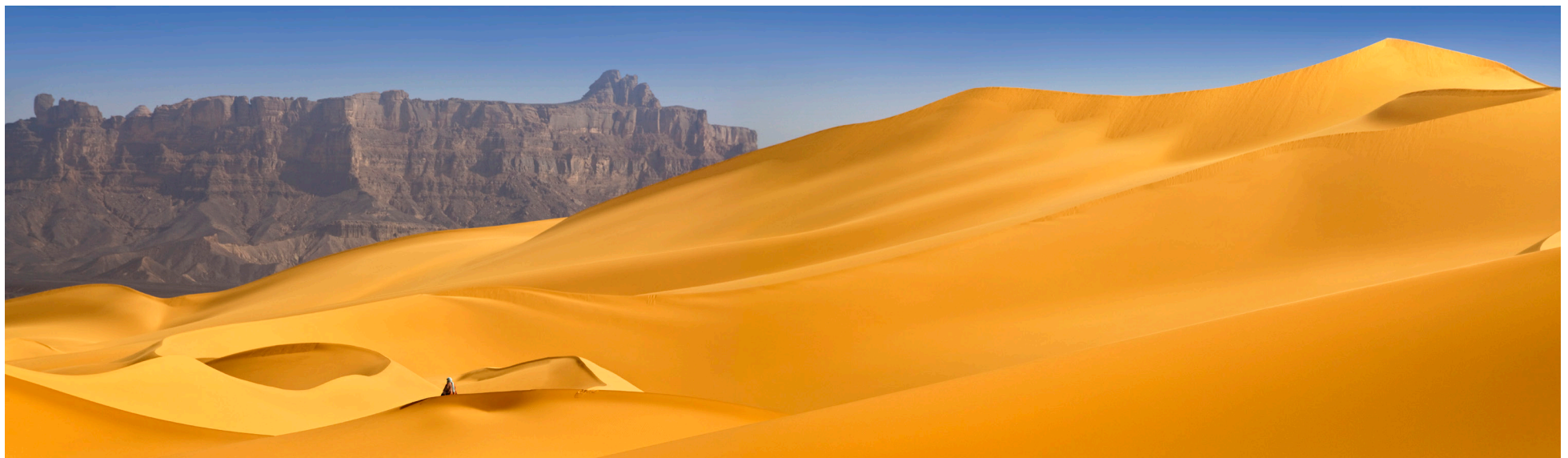
The high solubility of potash salts means there are particular problems and hazards associated with the utilization of bedded and halokinetic potash. Pervasive natural karst typifies all past and present salt deposits and effects of these natural geohazards can be increased if

flood possibilities are not accounted for from the sinking of the first shaft and throughout the life of the mine.

Topics: Keep it in the "salt;" Natural or not; Identifying the problem



Course No. 2275



NON-POTASH SALINES





Lithium pans, Atacama



Lithium saturation pond, Atacama

LITHIUM BRINES

In the last two decades, Chile has emerged as the world's largest lithium-carbonate producer from a lake brine, largely through the exploitation of Salar de Atacama, Chile, followed by China with operations focused in the Qaidam Basin and small-scale operations at Lake Zabuye.

Quaternary lithium brines accumulations are latitudinally restricted to cool arid belts within endorheic continental brine sumps.

Topics: Brine chemistry; climatic controls; Porosity limitations; Predictive models



Course No. 2325



Harvesting salt Onslow, NW Australia



Dampier Salt, NW Australia

SODIC SALTS

Natural sodium bicarbonate and sodium sulfate salts, as well as sodium chloride, supply significant volumes of feedstock to the world's industrial chemicals industries. The various salts precipitate with textures and mineral suites indicative of their formative

hydrology and tectonic settings. Utilizing this knowledge enables the construction of predictive models.

Topics: Soda-ash geology; Salt-cake geology; Sodium chloride plants; Climate & brine state



Course No. 2350



Colemanite-ulexite



Kramer Borax mine, USA

BORATES

Major commercial borate deposits occur in a limited number of Neogene to Holocene non-marine evaporitic settings, related to volcanic rocks and pyroclastic deposits in closed-basin alkaline lakes fed by hydrothermal waters. They are open-pit mined at the

Kramer mine in Boron California, in the Kirka ore district of Turkey, and Tincalayu in northern Argentina.

Topics: Boron chemistry; Sites of enrichment; Tectonic association; Predictive models

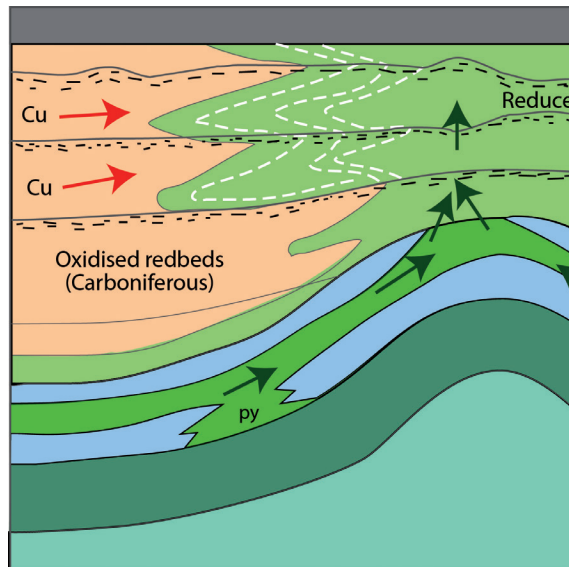


Course No. 2375



METALS AND SALTS





STRATABOUND COPPER

Sediment-hosted stratiform copper deposits worldwide rank second only to porphyry copper deposits in terms of copper production and are the most important global source of cobalt. Most are stratabound and are more or less concordant or peneconcordant,

either with saline beds, or with the edge of a salt mass or its residues.

Topics: Low T Cu carriers; Giant bedded ore; Giant halokinetic ore; Predictive textures



Course No. 2325



Galena, Cadjebut, Australia



McArthur HYC, Australia

Pb & Zn (MVT AND SEDEX)

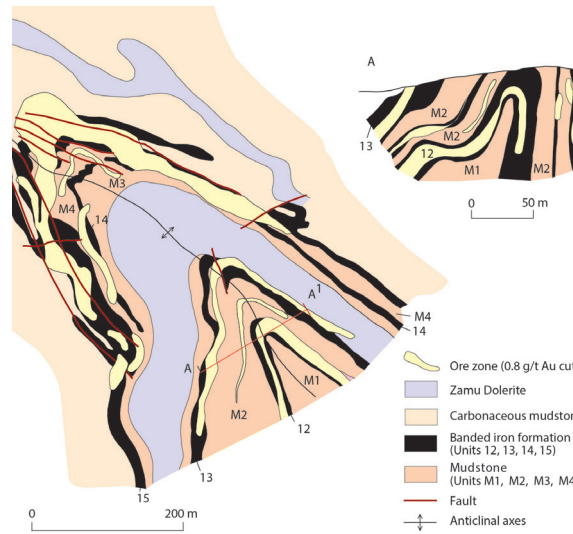
Many larger carbonate-hosted Pb-Zn deposits within the MVT and SedEx groups are associated with salt-sourced hypersaline ore fluids. They tie to dissolving halokinetic salt supplying and focusing metalliferous Cl-rich waters. Precipitation sites are typically

former platform sulfate levels that altered in burial, so supplying CaSO_4 to sulfate reduction fixation loci (BSR or TSR).

Topics: Low T Pb & Zn carriers; Evaporitic MVT deposits; Evaporitic SedEx deposits; Base metals & diagenesis



Course No. 2350



HIGH TEMPERATURE SALINE ORES

Metalliferous fluid indicators and ore deposits due to direct and indirect interactions between magma, evaporites, and their hydrothermal and metamorphic daughters, which at regional and local scales are neither well documented, nor well understood.

Mostly, this is because little or no actual salt remains once these high-temperature interactions run their course.

Topics: High-T saline system; Meta-evaporite gems; Orthomagmatic ores; Paramagmatic ores; IOCG deposits

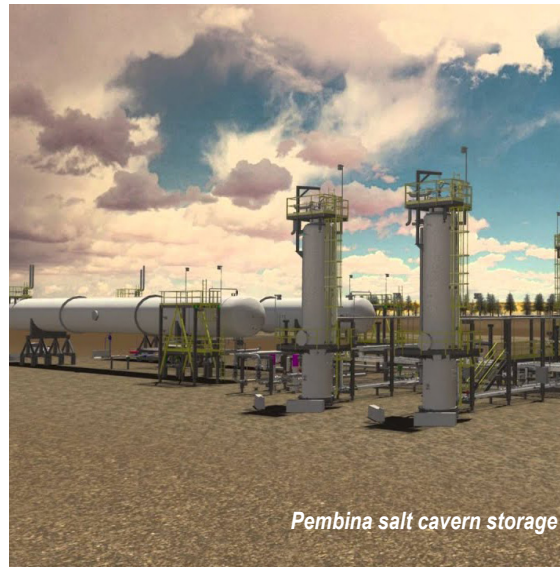
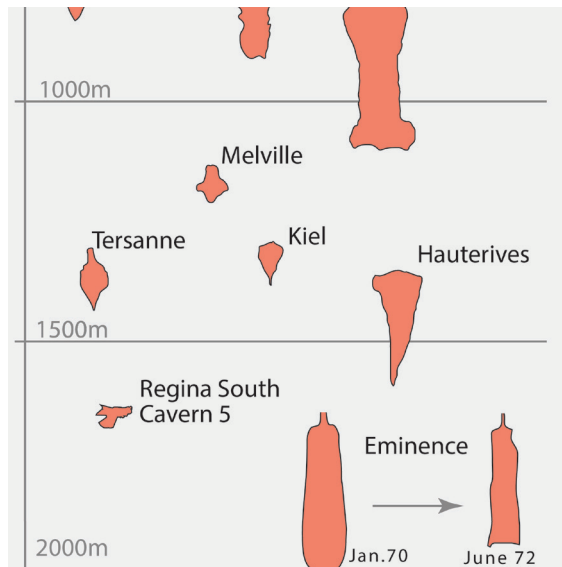


Course No. 2375



OTHER SALINE TOPICS





SOLUTION MINING

Salt solution mining is the mining of various salts, via dissolution, to create a purpose-built extraction or storage cavity. It requires pumping the brine liquor to the surface. There, the extracted brine can be concentrated or processed. For example, solution mining

for potash exploits folded and disturbed beds or deep-lying salt strata, situations not easily mined using conventional techniques.

Topics: Mining techniques; Residues and blinding; Operations & geology; Monitoring



Course No. 2425



META-EVAPORITES

Evaporite salts can survive well into the metamorphic realm, but are altered, recrystallised or transformed into new minerals and brine solutions. And so, beyond the early greenschist phase, little of the original sedimentary mineral phase remains (except anhydrite), but scapo-

lites, tourmalines, albitites, etc., do, along with various indicator textures.

Topics: Metamorphism; Indicator minerals; Gems from brine; Case histories



Course No. 2450



SALTY PROBLEMS

All evaporites tend to dissolve and, when salt beds or a halokinetic meta-evaporites are uplifted and so approach the surface, the rate of this dissolution tends to increase considerably. Hence, salt in regions where it is mined, or used to create cavities

for liquid or waste storage, can occasionally be susceptible to unexpected cavity enlargement, collapse and ground subsidence.

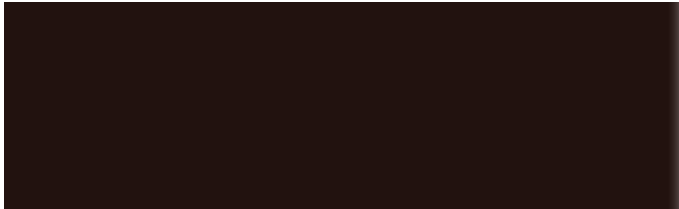
Topics: Collapsing brinefields; Leaky oilfield wells; Leaky caverns; Safety issues; Solving the problem



Course No. 2475



WHO & WHAT



PRINCIPAL TRAINER

Dr. John Warren is the leading expert and technical coordinator for Saltworks. His career spans more than 30 years in salty systems.

Interests include; Wireline Analysis, Carbonate and Evaporite Systems, Oil and Gas, Economic Geology and Potash exploration and development.

He has written four books on economic aspects of evaporites, has contributed related chapters in a number of books and has published more than 60 scientific articles in applied aspects of saline geology.



COURSE MATERIALS

All our course can be run remotely using Zoom or Microsoft Teams

Each participant in the course receives a complete set of digital course notes. This material is a series of hi-resolution pdf files that give the participant a copy of every slide presented during their training course.

In addition, each participant receives a digital copy of Dr. Warren's 2016 book "Evaporites: A compendium" published by Springer in 2016.

This online set of course notes in hard copy runs to more than 1800 pages and has been cited as the most complete summary of evaporites currently available.



SALT IS BORN OF THE PUREST PARENTS, THE SUN AND THE SEA .

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