GEOLOGICAL TIME SCALE

AGE OF THE EARTH 4.6 - 5.0 BILLION YEARS

THIS TIME SPAN IS DIVIDED INTO INTERVALS - BASIC DIVISIONS FOR GEOLOGICAL TIME SCALE

THESE INTERVALS ARE NAMED ON THE BASIS OF ROCKS FORMED WITHIN THEM;

WERE GIVEN NAMES AND CALIBRATED IN YEARS TO PRODUCE GEOLOGICAL TIME SCALE

A MEANS OF MEASURING EARTH'S HISTORY - A CALENDAR FOR EVENTS IN EARTH'S HISTORY

EARTH'S HISTORY IS MEASURED BY GEOLOGISTS USING TWO SCALES
(1) CHRONOLOGICAL AND (2) STRATIGRAPHIC

CHRONOLOGICAL HISTORY/AGE -- IN YEARS
STRATIGRAPHIC AGE -- ORDER OF EVENTS

STRATIGRAPHIC ORDER - IS THE ORIGIN OF THE SERIES OF GEOLOGICAL TIME INTERVALS
most widely used measures (units) of geological time

TO DATE EVENTS DIRECTLY (CHRONOLOGICAL DATING) REQUIRES SPECIAL TECHNIQUES

SO, GEOLOGISTS USE STRATIGRAPHIC UNITS -- A SYSTEM OF NAMED INTERVALS

For Example - A rock containing fossils of trilobites - means, the rock formed at a time when trilobites were alive and well

____ further, all rocks around the world that contain fossils of trilobites must have formed during the many millions of years when the creatures (trilobites) existed -- neither before they evolved, nor after they became extinct

____ still, looking more closely at the fossils shows that there are many species of trilobites, some evolving before others and some dying out earlier; that means a particular combination of fossils must have formed in the particular interval of time when those creatures lived

____ so, if we can identify the critical fossils, we can understand how old the rock is

____ then, an attempt will be made to match the interval of time to a sequence of named intervals

____ GEOLOGISTS HAVE ESTABLISHED THIS SEQUENCE BY LOOKING AT OUTCROPS OF ROCK, DECIDING WHICH ROCKS ARE OLDER AND WHICH ONES ARE YOUNGER, THEN ANALYSING FOSSIL RECORD IN DETAIL

____ THIS SEQUENCE IS THE STRATIGRAPHIC SCALE, THE STARTING POINT FOR THE GEOLOGICAL TIME SCALE

TYPES OF DATING

____ SEDIMENTARY ROCKS FORM IN LAYERS/STRATA -- REGULAR PATTERNS

____ THE DEEPER THE ROCK THE OLDER IT IS

____ GEOLOGICAL STRATA ARE COMPLEX; SEQUENCES OF SEDIMENTARY ROCKS CAN INCLUDE BREAKS, OR DISCONTINUITIES, WHERE ROCKS DID NOT FORM OR WERE ERODED AWAY; AND, NOT ALL TYPES OF ROCKS FORM LAYERS

____ IGNEOUS ROCKS CAN OCCUR IN LAYERS, BUT MORE OFTEN MUCH LESS REGULAR; METAMORPHIC ROCKS FORM FROM IGNEOUS AND SEDIMENTARY ROCKS, WITH NEW MINERALS, NEW DISPOSITION ETC.,

____ MOVEMENTS IN THE EARTH'S CRUST CAN EVEN FOLD OLD SEDIMENTARY LAYERS ONTO YOUNGER ONES

SO, ALTHOUGH STRATIGRAPHERS ARE ABLE TO TELL THE SEQUENCE OF EVENTS FROM STRATA, THEY CANNOT TELL *HOW MANY YEARS AGO* THE ROCKS FORMED

TO DATE ROCKS CHRONOLOGICALLY, WE NEED TO PINPOINT PARTICULAR EVENTS WITHIN A STRATA AND FIND OUT HOW MANY YEARS AGO THEY HAPPENED

___ IF THIS CAN BE DONE FOR SEVERAL DIFFERENT TIMES, STRATIGRAPHIC TIME SCALE CAN BE CALIBRATED AND ESTIMATE THE AGE OF ROCKS THAT FORMED BETWEEN THE KNOWN TIMES

THE BEST TOOL TO FIND OUT AGE OF ROCKS IS *RADIOMETRIC DATING* -- A TECHNIQUE BASED ON THE DECAY OF RADIO ACTIVE ISOTOPES (an atom of an element having a different nuclear mass - atomic weight - from other atoms of the same element - chemically both are same) IN THE ROCK

RADIOMETRIC DATING

IS BASED ON THE DECAY OF UNSTABLE ATOMIC NUCLEI

IT IS KNOWN WHEN A SINGLE NUCLEI WILL DECAY - USUALLY EXPRESSED AS *HALF LIFE*

___ ONE HALF-LIFE IS THE TIME IT WOULD TAKE HALF THE NUCLEI IN A SAMPLE TO DECAY

(If we start with a 1,000,000 atoms of an isotope with a half-life of 100 years, half of them (5,00,000) will remain after 100 years and half of that half (2,50,000) will remain after another 100 years; thus, as time passes, a rock will contain fewer of the radioactive nuclei and more of the isotopes produced)

___ AS WE KNOW HOW LONG A PARTICULAR ISOTOPE TAKES TO DECAY, WE CAN USE THE AMOUNT LEFT IN A ROCK AT PRESENT TO CALCULATE *WHEN* IT FORMED

___ RADIOMETRIC DATING IS A POWERFUL TECHNIQUE BUT IT HAS IMPORTANT LIMITATIONS, NOTABLY THAT IT CANNOT GIVE A DIRECT DATE FOR THE DEPOSITION OF THE SEDIMENTARY ROCK

___ SEDIMENTARY ROCKS DO NOT USUALLY HOLD THE RIGHT KIND OF ISOTOPES; BUT, RADIOMETRIC AGES CAN BE ASSIGNED TO SEDIMENTARY ROCKS USING THE STRATIGRAPHIC TIME SCALE

___ A LAVA FLOW WILL BE YOUNGER THAN THE ROCKS IT ERUPTS ONTO AND OLDER THAN THE SEDIMENTARY ROCKS THAT SETTLE ON TOP OF IT

___ LAVA IS AN IGNEOUS MATERIAL/ROCK SUITABLE FOR RADIOMETRIC DATING, SO THIS LAYER CAN PRODUCE A CHRONOLOGICAL AGE

___ AND IF THE SEDIMENTARY LAYERS CAN BE MATCHED WITH OTHERS OF THE SAME AGE AROUND THE WORLD, THEN THE AGE OF THE LAVA FLOW CAN BE APPLIED TO MANY SEQUENCES OF ROCKS

STRATIGRAPHIC PRINCIPLES

STRATIGRAPHERS BUILD THE GEOLOGICAL TIME SCALE BY STUDYING AND CORRELATING STRATA OVER WIDE AREAS

THE TASK IS DIFFICULT BECAUSE NATURE DOES NOT DEPOSIT ROCKS IN REGULAR LAYERS

THE SEDIMENTS THAT EVENTUALLY BECOME ROCK COLLECT IN LOW AREAS SUCH AS THE SEA, WHILE EROSION WEARS DOWN THE MOUNTAINS; EVEN WITHIN THE SEA DIFFERENT ROCKS FORM IN DIFFERENT AREAS, COMPLICATIONS COME BECAUSE OF SEA LEVEL CHANGES

TO MAKE SENSE OF SUCH DEPOSITS, GEOLOGISTS MATCH ROCKS IN DIFFERENT AREAS BY MATCHING WHAT WAS HAPPENING, WHEN THEY FORMED

ALL THESE FACTORS MEAN THAT ROCK OF THE SAME AGE CAN LOOK QUITE DIFFERENT FROM ONE PART OF THE WORLD TO ANOTHER, DEPENDING ON WHETHER THE REGION WAS LAND OR SEA, QUIET LAKE OR FAST FLOWING RIVER

STRATIGRAPHIC STUDIES HELP US TO MATCH ROCK UNITS OF DIFFERENT PLACES

TEAMS OF GEOLOGISTS COMPARE SEQUENCES OF ROCKS OF THE SAME AGE AROUND THE WORLD AND SELECT THE ONE THAT IS THE MOST COMPLETE WITH THE DETAILED LAYERING AND THE MOST USEFUL FOSSILS

THIS BECOMES THE TYPE SECTION DEFINING THAT PARTICULAR BOUNDARY; OTHER BOUNDARIES AT DIFFERENT TIMES, WILL HAVE THEIR OWN TYPE SECTIONS, CHOSEN WHERE THE ROCKS CONTAIN THE MOST DETAILED INFORMATION

ALL OTHER ROCKS AROUND THE SAME AGE ARE COMPARED TO THIS SECTION TO FIND OUT THEIR STRATIGRAPHIC AGE

BUT THIS METHOD DEPENDS ON BEING ABLE TO CORRELATE ROCKS THAT FORMED AT EXACTLY THE SAME TIME

TO ESTABLISH WORLD-WIDE CORRELATIONS, STRATIGRAPHERS NEED TO FIND *MARKERS* THAT THEY KNOW FORMED AT EXACTLY THE SAME TIME AND THAT THEY CAN RECOGNISE OVER LARGE AREAS

THE IDEAL WOULD BE SOME RECOGNISABLE MATERIAL SPREAD OVER THE ENTIRE GLOBE IN A GEOLOGICAL INSTANT - EXAMPLES - IRIDIUM RICH DUST FROM THE ASTEROID IMPACT AT THE END OF THE CRETACEOUS PERIOD 65 MILLION YEARS AGO; LARGE VOLCANIC ERUPTIONS, SCATTERING ASH OVER LARGE AREAS, ARE MORE FREQUENT AND THE ASH CAN HAVE A DISTINCTIVE CHEMICAL SIGNATURE

SUCH WORLD-WIDE OCCURRENCES OF MARKERS ARE RARE

STRATIGRAPHERS USE OTHER WIDELY DISTRIBUTED MARKERS -- *FOSSILS*

THE *INDEX FOSSIL* FOR DATING IS ONE THAT IS COMMON AND EVOLVED RAPIDLY

THE DATING HIERARCHY

MANY OF THE DIVIDING LINES IN GEOLOGICAL TIME SCALE MARK TIMES OF GREAT CHANGE ACROSS THE FACE OF THE EARTH

FIRST FOSSIL EVIDENCE OF LIFE IS TAKEN TO MARK THE START OF THE CAMBRIAN PERIOD

THE ENTIRE EARLIER TIME BEFORE CAMBRIAN IS CALLED PRECAMBRIAN

THE PRECAMBRIAN-CAMBRIAN BOUNDARY IS THE BROADEST DIVISION OF THE GEOLOGICAL DATING HIERARCHY

THE LARGEST DIVISIONS ARE CALLED *EONS/AEONS*

THE FIRST 2 BILLION YEARS OF THE EARTH'S HISTORY ARE USUALLY CALLED THE ARCHEAN EON; ITS END IS SET AT 2.5 BILLION YEARS AGO WHEN THE SURFACE OF THE EARTH WAS ON THE MODERN PATTERN OF PLATE TECTONICS

THE EARLIEST PART OF THE ARCHEAN EON -- AND OUR PLANET'S HISTORY -- WAS *HADEAN TIMES* WHEN THE EARTH WAS SO HOT THAT THERE WAS NO STABLE SOLID CRUST

THE PROTEROZOIC EON SPANS THE TIME FROM 2.5 BILLION YEARS AGO UNTIL HARD SHELLED ANIMALS APPEARED

PRECAMBRIAN INCLUDES BOTH ARCHEAN AND PROTEROZOIC EONS

THE FOLLOWING HALF BILLION YEARS ARE THE PHANEROZOIC EON, WHICH IS SUBDIVIDED IN GREAT DETAIL BECAUSE GEOLOGISTS KNOW MUCH MORE ABOUT IT THAN ABOUT EARLIER EONS

THREE *ERAS* MAKE UP THE PHANEROZOIC EON; THE *PALAEOZOIC ERA* OF 'EARLY LIFE', *MESOZOIC ERA* OF 'MIDDLE LIFE' AND *CENOZOIC ERA* OF 'RECENT LIFE'

THESE DIVISIONS ARE BASED ON CHANGES IN FOSSILS

ERAS ARE BROKEN INTO *PERIODS* WHICH ARE MOSTLY NAMED AFTER CHARACTERISTIC ROCKS OR THE AREAS IN WHICH THEY APPEAR

TERTIARY -- DESCRIPTIVE TERM -- *EOCENE, MIOCENE, PLIOCENE, OLIGOCENE AND PALEOCENE* – ON THE BASIS OF RELATIVE PROPORTIONS OF LIVING AND EXTINCT FOSSILS IN EACH

JURASSIC -- STRATA OF JURA MOUNTAINS IN NORTHERN SWITZERLAND

CRETACEOUS -- TERM DERIVED FROM LATIN WORLD FOR CHALK -- PARIS BASIN WITH CHALK, SANDSTONE AND SHALE

CARBONIFEROUS -- COAL BEDS IN CENTRAL ENGLAND

QUATERNARY -- DESCRIPTIVE TERM -- PARIS BASIN – INCLUDES *PLEISTOCENE AND HOLOCENE* SERIES

TRIASSIC -- IN GERMANY

CAMBRIAN AND SILURIAN -- ANCIENT WELSH TRIBES

DEVONIAN -- ROCKS OF DEVONSHIRE IN S. ENGLAND -- IN BETWEEN SILURIAN AND CARBONIFEROUS

PERMIAN -- PROVINCE PERM IN RUSSIA -- GREAT THICKNESS OF LIMESTONE OVERLIES THE CARBONIFEROUS

MISSISSIPPIAN -- MISSISSIPPI VALLEY -- WELL EXPOSED LOWER CARBONIFEROUS STRATA