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Forming Concepts and Strengthening Vocabulary in Earth Sciences through Etymology

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Abstract:

Many technical terms used in the Earth sciences are derived from foreign languages such as Greek and Latin and are not easily comprehensible to beginners. However, knowledge of the root words from which these technical terms are formed not only makes learning of the concepts represented easier, but also helps to quickly understand new terms that may be encountered. This paper considers about 1,600 technical terms that derive from about 300 root words. Learning the Earth sciences vocabulary thus reduces to learning a much smaller assortment of root words. Dominant contributors to the vocabulary are the Greek root words *isos, lithos, gennaine, ge, klinein, morphe, meta, orthos, para, klasis, chronos, pseudes*, *strophe, tropos* as well as some Latin roots such as *stratum, fluvius,* etc. As language skills usually develop quite early and new vocabulary is acquired more slowly with age, a genetic treatment of the Earth science vocabulary early on is expected to help the student develop a keen aptitude and an enduring interest in the subject.

Key Words

Earth sciences, geoscience, technical terms, origins, curriculum, etymology, language skills, communication skills

1. Introduction

Events and processes in the solid Earth, atmosphere, oceans, climate and extra terrestrial objects that together constitute the Earth system, have a consequence on the existence and well being of mankind. The study of Earth is of interest to not only the student receiving formal instruction as part of a structured curriculum, but also to the common citizen with concern for things around him. Earth sciences are also the most cosmopolitan of the various science disciplines since they embrace diverse subjects such as geology, physics, chemistry, biology and mathematics. A new learner in Earth sciences can be confounded by an exotic range of technical terms that are difficult to understand and remember. Glossaries do give definitions of Earth science terms but do not present a genesis of the word that can possibly make the task of understanding and remembering easier. The problem is particularly acute for students coming from different ethnic backgrounds who find it difficult to cope with cultural barriers on one hand and a language barrier on the other. Interestingly, it can be found that a large number of technical terms are derived from many fewer root words that are usually of Greek, Latin or German origin (Schwarz et al., 1986; Brown, 1956; Sarma, 2004; Sarma, 2005). It is these root words that constitute the more difficult parts of the terms.

Thus, the task of understanding the expansive list of esoteric terms can be reduced to understanding these few root words.

For example, “Earth science” can be considered a layman’s term for “geoscience”. From the Greek root *ge,* meaning “Earth”, are formed numerous terms that represent various branches and sub-branches of study and also phenomena, e.g., geography, geology, geophysics, geochemistry, geomagnetism, geomorphology, geochronometry, geodesy, geoid, geostrophic, etc. These terms contain additional affixes of Greek origin e.g., “graphy” (*graphein* to write) “logy” (*logos* discussion, study), “morpho” (*morphe* shape), “chrono” (*chronos* time) “meter” (*metron* measurement), “detic” (*daisis* division), “oid” (*eidos* form), “strophic” (*strophe* a turning) and so on. Let us look closely at the more exotic combinations – “geochronometry” is measurement (*metron*) of time (*chronos*) when the events occurred on the earth (*ge*). “Geodesy” is measurement (*desy*) of Earth on large scale, i.e., surveying with allowance for its curvature. “Geostrophic” stands for turning or bending (*strophe*) of a vector (such as wind or ocean currents) due to the rotation of Earth. The additional affixes of the terms namely chrono, homo, kata, and strophe in turn constitute numerous other terms given in Table 1, and the chain continues. In this chain, familiar terms and their familiar root words are a gateway to learn new terms and their new affixes, and so build a more complete vocabulary of Earth science terms.

Table 1: Additional reading for roots (all of Greek origin) producing multiple terms

Part A: Terms deriving from (linked to) roots already discussed		
Root	**Terms**	**D**
chronos	chronolith	G
	diachronous	G
	heterochronism	G
homo	homocline	P
	homodetic; Opp. heterodetic	C
	homologue,	C
	homopause,	P
	homosphere	P
kata down, under	cataclasis	G
	catazone,	G
	isanakatabar	M
	katabatic,	M
	katallobaric,	M
strophe a turning	apostrophe	A
	catastrophism,	G
	cyclostrophic,	M
	diastrophism,	G
lithos stone		Table 8
Part B: Terms deriving from (linked to) new roots in Part A terms		
dia through, across		Table 2
heteros other		Table 2
klasis breaking		Table 11

The influence of Greek and Latin is perhaps greatest in medical literature. Recognizing the need to explain medical terms to modern day practitioners and students who are not proficient in classical Greek and Latin, Dunmore and Fleischer (1977) both linguists, published a novel approach to teaching the challenging language of medicine that involved teaching students to recognize the roots of medical terminology. This concept has been pursued further by medical professionals working in collaboration with a linguist, as evident from the recent revision of this popular treatise (Walker-Esbaugh et al., 2004). Medical terminology constitutes course curricula world over (Stiles, 2000). However, in the case of science disciplines, including Earth sciences, the origins of most technical terms are unavailable in present day textbooks and appear to be forgotten or ignored. Explaining the origins of terms in a class is left mostly to the knowledge, experience and interest of individual teachers.

2. Methodology

Language skills usually blossom quite early, but unfortunately also wane off as one advances in age. A genetic treatment of the Earth science vocabulary provided to the student early on may help him or her develop an aptitude for the subject in the formative stage. As a first step, my endeavor is to take the student and possibly educators to the roots of technical terms so that there can be a wider discussion amongst them before any serious case is made for their formal inclusion in curriculum. One possible approach in the class room is to assign a small set of root words specific to each lesson or lecture, and in a cascading manner build vocabulary by topic, chapter, and discipline. Root words do overlap across the disciplines but usually a given set of roots is more commonly associated with a particular topic. As the curriculum architect, the instructor must find a suitable place for each term in the lesson plan.

In my university classes, I have practiced an etymological approach and through feedback from students have recognized the merit of this approach for explaining concepts in lucid and appealing language. I have observed a distinct improvement in the communication skills of the students. The merit of the root-based study is also evidenced from my own experience. I am not formally educated in Earth science, but have become more proficient in Earth science by self-learning in which the etymological approach has played a key role.

I initially prepared an extensive list of technical terms in current popular usage from standard textbooks of Earth sciences covering important branches (Ernst, 2000; Emiliani, 1992; Bearman, 1989/1991; Harvey, 1982; Barry and Chorley, 1976; Pettijohn, 1975) and from science dictionaries (Parker, 1994; Collocott and Dobson, 1986). Sifting this list gave rise to about 1,600 technical terms containing root words of non-English origin. With the help of etymological sources (Schwarz et al., 1989; Brown, 1956) and from my works in chemistry (Sarma, 2004, 2005, 2006), I then probed how the terms are constituted *vis a vis* their actual significance explained in the above Earth sciences literature. In this exercise, an accurate dissection of each term into its appropriate component root words is a matter of early concern. Particularly, when the prefix ending in a vowel has to be joined to a stem word that starts with a vowel or the letter “h”, the ending vowel disappears, e.g., isanomalous (iso+anomalous), geanti (geo+anti),

ephemeral (epi+hemeral; Gr. *hemera* a day), epeiro (*epi+eiro;* Gr. *epeiros* mainland), catallo (*cata+allo*), etc. In terms such as "anallo" (*ana+allo*), particular caution is necessary since the prefix could be "an" too, in which case the meaning would just be the opposite.

Often, etymological origins are not readily available, and an intensive cross-consultation within the sources referred above is needed. In my first attempt, I arranged the root words in an all-embracing alphabetized list, and then complemented them with various terms that derive from them. Using this as the database, I then identified different topics under which the terms could better be clustered. Finally, I carefully prepared the textual account sequencing the topics and terms so that the account steers clear of monotonous redundancies and terms are explained in a generally sequential order of understanding, though refinement is possible.

In the text, I have limited myself to discuss single examples, and have preferred to provide more examples in the Tables as an exercise for the student. Each table consists of two parts – Part A dealing with terms deriving from roots already discussed in the text and Part B with terms deriving from the new roots of terms in Part A. Roots and their examples that could not be included in any of the identified topics are given as a miscellaneous collection in the last Table. The specific discipline ('D' in Tables) to which the term most commonly belongs is also mentioned as abbreviation i.e., A, B, C, G, M, O, P standing for All (i.e., of general usage), Biology, Chemistry, Geology-Geophysics-Geography, Meteorology, Oceanography (and Limnology) and Physics respectively. The abbreviations Gr., L., Ger., Cel. are for Greek, Latin, German and Celtic respectively throughout the article.

3.1. Biological terms (Table 2)

The hierarchical division of species is called taxonomy (Gr. *taxis* arrangement; *nomos* law) in which the names given can give a clue to their morphological (Gr. *morphe* shape) features. Plankton (Gr. *planktos* wandering) essentially wander around while nekton (Gr. swimming) are capable of swimming. *Benthos*, meaning depth in Greek is in particular reference to living organisms on the bottom of a large body of water, while the roots *bathys* and *bathos*, also meaning depth in Greek give rise to several terms appearing in Table 2. *Foram* is a small opening, and *ferous* bearing in Greek occurring in "foraminifera", small shelled marine protozoans. In "diatoms", *dia* means "through" and *tomos* "to slice" in Greek. Diatoms are a class of microalgae that have flinty shells in two halves (fitting like box and lid). The order radiolaria (L. *radius* a rod) are pseudopodia (Gr. *pseudos* false; *podos* foot) having a radial structure. Coccoliths (Gr. *kokkos* a berry) have shape similar to berries. Pteropods, pelecypods, and brachypods derive their common group names from the shape of their swimming organs. Ctenodonts are recognizable from their characteristic comb-like tooth structure. The skeletal remains of these organisms constitute ooids (Gr. *oion* egg, roe of fish; *eidos* form), formerly referred as oozes. "Bioherm", a moundlike mass of sediment built up by underwater organisms, owes its name to *Hermes,* the Greek god responsible for boundaries. A herm is a vertical stone boundary marker.

Table 2: Additional reading for roots producing multiple terms of Section 3.1

Part A: Terms deriving from (linked to) roots already discussed

Root	Terms	D
Gr. *bathos* depth	bathocuproin	C
	batholith	G
	bathophenathroline	C
	bathyal (zone)	O
	bathymetry	O
	bathythermograph	O
Gr. *dia* through	adiabatic	C
	diagenesis	G
	diamagnetism	C
	diastrophism	G,O
Gr. *eidos* form	amygdaloid	G
	batryoid	G
	geoid	G
	lingualoid	G,O
	ooid	G
	pinacoid	G
	spheroid	P
Gr. *ferous* bearing	aquifer	G
	argelliferous	G
	auriferous,	G
	carboniferous	G
	ferriferous	G
	petroliferous	G
Gr. *nomos* law	astronomy	P
	economy	A
Gr. *odontos* tooth	anomalodont	B
	asthenodont	B
	ctenodont	B
	dysodont	B
	heterodont	B
	taxodont	B
Gr. *phorein* to bear	chromophore	C
Gr. *planktos* wandering	phytoplankton	B
	zooplankton	B
Gr. *podos* foot	brachypods	B
	pelecypods	B
	pteropod	B
Gr. *pseudos* false	pseudoconformity	G
	pseudomicroseism	G
	pseudo-oolith	G
	pseudosymmetry	C,G
	pseudovolcano	G
Gr. *taxis*	eutectic	C,G

*a*rrangement		
	orthotectic (stage)	G
	peritectic	G
	phototaxis	B
	pneumatotectic	G
	syntectic	G
	taxon	B
Gr. *tomos* to slice	appendectomy	B
	atom,	C
	microtome	B
	tomography	B

Part B: Terms deriving from (linked to) new roots in Part A terms

Gr. *amygdale* almond	amugdule	G
L. aqua water	aquifer	G
	aquifuge	G
	aquitard	G
Gr. *astron* star	astrophysics	P
Gr. *brachys* short	brachypinacoid	B
Gr. *chroma* color	chromosome	B
L. *con* together	connate (water)	G
Gr. *ctenos* comb	ctenophora	B
Gr. *hedra* base	octahedral	C
Gr. *eu* well	eutrophic	O
	euphotic	O
	eustasy	O
	euhedral	G
Gr. *oikos* a house	ecology	B
Gr. *oion* egg	oolith	G
Gr. *pelekys* axe		
Gr. *peri* around	periscope	A
Gr.*phos* light	dysphotic	O
	euphotic	O
	photosynthesis	B
Gr. *phyton* plant	Chlorophyte	B
	Paeophyte	B
	prasinophyte	B
	rhodophyte	B
Gr. *pneumatos* breath	pneumatic pump	A
Gr. *pteron* wing	pteridophyta	
Gr. *seismos* a shaking	seismic (belt)	G
L. *tardus* slow	tardy (growth)	A
Gr. *zoe* life	zoogeography	B

3.2. *Limnology and Oceanography* (Table 3)

Mi(n)ctio is urination. *Mictic* of dimictic, meromictic, holomictic, polymyctic and so forth stands for circulation. Meromictic (Gr. *meros* part) for example, is with regard to a lake whose water circulates only in confined parts, for example at the surface. Usually, the lake top constitutes the mixolimnion (Gr. *mixis* mixing) layer and bottom, the monimolimnion layer (Gr. *monimos* stable, steadfast). In Latin, *fluvius* is river, cf., fluvial. Pluviofluvial (L. *pluvia* rain) pertains to the combined action of rainwater and streams.

Pelagos and *thalassa*, both mean sea in Greek; the former refers to the open sea and the latter to a confined sea. Hence, abyssopelagic (Gr. *a* without, *byssos* depth, cf., abyssal) pertains to open waters of the abyssal zone. Panthalassa (Gr. *pan, panto, pantos* in composition all) on the other hand pertains to all parts of the ocean combined; it is the hypothetical proto-ocean (Gr. *protos* first).

Nephele is cloud in Greek. The nepheloid (*eidos* like, see before) layer is cloudy due to the presence of re-suspended sediment. Regimes of changing physical, chemical or biological properties have terms ending in “cline”, e.g., thermocline (Gr. *klinein* to lean; *thermos* heat, actually temperature).

Table 3: Additional reading for roots producing multiple terms in Section 3.2

Part A: Terms deriving from (linked to) roots already discussed

Root	Terms	D
Gr. *a* without	abyssal	O
	asthenosphere	G
Gr. klinein	halocline	O
	lysocline	O
	pycnocline	O
Gr. *meros*	centromere	B
	isomer	C
	polymere	B
Gr. Nephele cloud	isoneph	M
	nephsystem	M
Gr. pan	pangea	G
	panautomorphic	G
	panfan	G
	panplain	G
Gr. protos first	protointraclast	G
	protostratigraphy	G
Gr. thermos heat	bathythermograph	O
	thermoluminescence	P

Part B: Terms deriving from (linked to) new roots in Part A terms

Gr. *hals* salt	halogen	C
Gr. *hals* salt	halite	C, G
Gr. *leiin* to loosen	dialysis	C
	electrolysis	P
	halmyrolysis	G
	hydrolysis	C
	lyophilization	C
Gr. *pyknos* dense	pyknometer	P

3.3. *Meteorology* (Table 4)

In the term "meteorology" (Gr. *meta* after; *aerien* to lift), the root word *aerein* signifies the lifting of air and water vapor caused by heating. The lines of constant value of an atmospheric property plotted on a map are called isopleths (Gr. *plethos* a great number) or isarithms. Examples of specific properties include: isohel (Gr. *helios* sun) for sunshine, isohyet (Gr. *hyetos* rain) for rainfall, isoneph (Gr. *nephele* cloud, see Section 3.2) for cloudiness and isotach (Gr. *tachys* swift) for wind speed. Isobront (Gr. *bronte* thunder), also called homobront (Gr. *homos* same) refers to simultaneous occurrence of phases of a thunderstorm, isopectic (Gr. *pektikos* congealing; L. *gelu* frost) to the times of winter when ice begins to form, and isothere (Gr.: *ther* a wild beast) to mean (unbearable) summer temperature.

Hygros is moist (cf., hygrometer) and *kinesis*, movement in Greek, constituting the term hygrokinematics. Among the different types of clouds, altostratus (L. *altus* high, cf., altitude; *stratum* layer, cf., stratosphere) cloud is much larger than for example, cirrocumulus (L. *cirrus* a tuft; *cumulus* a heap) cloud. Noctilucent (L. *nox*, *noctis* night; *lucis* light) clouds stand out against a dark night sky.
A Greek root similar in meaning to *strophe* (see Section 1) is *tropos.* The affix "tropic" is specifically used in the context of change (i.e., a turning) of a property in response to another. Tropics constitute the area of the celestial sphere (between 23°28'N and 23°28'S of Earth's equator) where the Sun appears to turn on reaching its greatest declination. Troposphere is a region where the temperature and pressure fall rapidly with height. The terms "barotropic" and "heliotropic", refer to changes involving pressure (Gr. *baros*) and diurnal radiation (Gr. *helios* sun) respectively. Isotropy (Gr. *isos* same) is the condition when physical properties, e.g., magnetic susceptibility or elastic constants, are same in all directions; in aniosotropy, the physical properties do vary with direction, e.g., magnetic anisotropy.

Table 4: Additional reading for roots producing multiple terms of Section 3.3

Part A: Terms deriving from (linked to) roots already discussed

Root	**Terms**	**D**
Gr. *gelu* frost	gelisol	G
Gr. *helios sun*	helium	C
	perihelion	P
Gr. *hygros* wet, moist	hygroscopic	M
L *lucis* light	lucid	A
	luciferous	P
L. *nox*, *noctis* night	equinox	P
	nocturnal	B

3.4. Geology

3.4.1. Names Rock and mineral names present a substantive topic requiring an extended study in and of themselves, and are not presented in this paper. As an example, the element iron is *ferrum* in Latin and *sideros* in Greek, resulting in the mineral siderite (iron carbonate). The latter root word is some times misleading as *sideris*, the Latin root means star (cf., siderial). Haematite (Gr. *haima* blood), the principal ore of iron gets its name from its color.

3.4.2. Texture Terms (Table 5)***:*** Porphyritic (Gr. *porphyros* purple) or blastoporphyric (*blastos* a sprout), poikilitic (Gr. *poikilos* variegated) and trachytic (Gr. *trachys* rough) are examples of texture terms.

Table 5: Additional reading for roots producing multiple terms of Section 3.4.2

Part A: Terms deriving from (linked to) roots already discussed		
Root	**Terms**	**D**
Gr. blastos a sprout	blastopsammite;	G
	xenoblastic,	G
Gr. poikilos variegated	poikiloblast	G
	poikilocrystallic,	G
	poikilophytic,	G
	poikilotope,	G
Gr. *porphyros* purple,	blastoporphyric	G
	glomeroporphyritic,	G
Gr. *porphyros* purple,	porphyroblastic or	G
	porphyroclastic,	G
	porphyrocrystallic,	G
Gr. *porphyros* purple,	porphyroskelic,	G
Gr. *porphyros* purple,	porphyrotope,	G
Part B: Terms deriving from (linked to) new roots in Part A terms		
L *glomus* ball	conglomerate	G

3.4.3. Cave Deposits (Table 6)

Speleothems (Gr. *spelaion* cave; *thema* deposit) consist of columnar deposits, e.g., stalagmites (Gr. *stalagmos* a dropping), cf., stalagmameter). Coincidentally, *stalag*, in German, is a base camp for the prisoners of war derived from *stamm* for base and *lager*, camp. Stalagmameter is an instrument for determining surface tension by drops. Stalactites (Gr. *stalaktos* a dropping) are so called because they are formed from the top out of the falling water drops.

Table 6: Additional reading for roots producing multiple terms of Section 3.4.3

Part A: Terms deriving from (linked to) roots already discussed

Root	**Terms**	**D**
Gr. *stalagmos* a dropping	stalagmameter	P

3.4.4. Geologic age terms (Table 7)

Eon (or *aeon*) meaning eternity in Latin, is the term applied for the main divisions of geological ages. Archaean (Gr. *archi* first) is the earliest eon. "*Aes*", in Latin is copper. Its plural, *aera* originally meant pieces of copper used in counting and stands for "a great number". Eras are divisions of the eons. "Palaeozoic" (Gr. *palaeo* ancient); *zoe* life), Mesozoic (Gr. *mesos* middle), Cenozoic, or Cainozoic or Kainozoic (Gr. *kainos* new), Proterozoic (Gr. *proteros* earlier) and Phanerozoic (Gr. *phaneros* visible) signify the extent of life that occurred in them. Epoch is a pause (Gr. *epi* upon; *echein* to hold). Holocene (Gr. *holos* whole) is wholly new; it is the current epoch. Going backwards in time, Pleistocene (Gr. *pleistos* most numerous), Pliocene (*pleion* greater, more numerous), Miocene (Gr. *meion* smaller), Oligocene (Gr. *oligos*, few) and Eocene have progressively smaller number of fossilized living mollusks. In Greek, *eos* means day break, signifying the starting of the appearance of these fossils in the Eocene. Pal(a)eocene (Gr. *palaios* ancient) is the earliest Epoch of the Tertiary. A recently coined term "anthropocene" (Gr. *anthropos* man) represents the era of humankind.

Table 7: Additional reading for roots producing multiple terms of Section 3.4.4

Part A: Terms deriving from (linked to) roots already discussed

Root	Terms	D
Gr. *anthropos* man,	anthropogenic	B
	anthropology	A
	philanthropy	A
Gr. *archi* first	archbishop	A
Gr. *epi* upon	epicentre	G
	epifauna	B
	epilimnion	O
	epipelagic	O
Gr. *holos* whole	holistic	A
	holohyaline	G
	holomictic	O
	holostratotype	G
Gr. *meion* smaller	meiofauna	B
	mesobenthos	B
	mesoclimate	M
	mesocyclone	M
	mesogeosyncline	G
	mesopause	P
	mesosphere	P
	mesostasis	G
	mesothermal	M
Gr. *oligos* few	oligomer	C
	oligosaccharide	C
	oligotrophic	B
Gr. *palaeo* ancient	paleoceanography	O
	Paleocene	G
	paleokarst	G
	paleontology	G
	paleopedology	G
	paleosol	G
	paleosome	G
	paleozoic	G
Gr. *phaneros* visible,	aphanetic	G
	phanerocrystalline	G
Gr. *pleion* greater, more numerous	pleochroism	G
	pleomorphic	G
Gr. *thema* deposit	eonothem	G
	speleothem	G
	synthem	G
Gr. *zoe* life	zooplankton	B
	zooxanthillae	B

Part B: Terms deriving from (linked to) new roots in Part A terms

Gr. *soma* body	chromosome	B
Gr. *spelaion*	cave	G

3.4.5. Common affixes

3.4.5.1. Lith/lite (Table 8)

The affix *lith*, or its variant *lite* occurs extensively in geological terms. *Lithos* is stone in Greek. *Lith* and *lite* occur as suffixes to names of several varieties of rock formations according to their area of genesis, mechanism of formation or shape and composition.

i. *Area and mechanism of formation* : Abyssolith, asthenolith (Gr. *sthenos* strong), laccolith (Gr. *lakkos* a reservoir), batholith indicate the source region of the formations. The prefixes "endo" (Gr. *endo* within, opposite: *exo* outside) and "acro" (Gr. *acros* topmost) occur as prefixes in some terms such as "endobatholithic" and "acrobatholithic". Tachylite (Gr. *tachys* swift) formed by sudden cooling of basalt may acquire a glassy texture to give hyalobasalt (Gr. *hyalos* glass). The term "rhyolite" (Gr. *rhyx* a lava stream, *rheos* flow) is from the stream of lava from which it is formed. Enterolith (Gr. *enteron* gut) formed in folds is shaped like the lobes of intestines. Saprolite (Gr. *sapros* rotten) is a soft partially decomposed rock. Xenolith (Gr. *xenos* strange) is not a native rock. An ereilite (Ger. *ur* primitive, original) is meteoritic in origin.

ii. *Shape:* Perlite, also spelled as pearlite (or pearlstone) produces pearl-like masses or pebbles on breaking. Spenolith (Gr. *sphenos* wedge) is a wedge-like (igneous) intrusion. Ethmolith (Gr. *ethmos* sieve) is sieve like (funnel shaped). Regolith (Gr. *regos* a blanket) is like a blanket cover. Phacolith (Gr. *phakos* a lentil) is lens-shaped. With lopolith (Gr. *lope* a cloak), sagging occurs at the center as in the case of cloak. Lithophysa (Gr. *physa* bellows) are bellow-shaped hollows. Zeolites (Gr. *zeiin* to boil) swell up under the blow pipe. Stromatolites (Gr. *stroma* a bed, mattress; plural: *stromata*) are laminated masses. Pisoliths (Gr. *pisos* peanut) are pea-shaped. Graptolite (Gr. *graptos* written, *graphein* to write) is like a writing upon shales. A rhabdolith (Gr. *rhabdos* rod) is rod-shaped.

iii. *Composition*: Pedolith (Gr. *pedon* ground, soil, cf., pedology, pedosphere, pedorelic, pediplain, pedocal) is formed by pedogenic processes. Phytocollite (Gr. *phyton* plant), anthraxolite (Gr. *anthrax* charcoal) and spongolite are so named also from their composition.

Stratigraphic units of rocks based on lithology are "geoliths" and those based on geologic age or time of origin are "chronoliths".

Table 8: Additional reading for roots producing multiple terms of Section 3.4.5.1

Part A: Terms deriving from (linked to) roots already discussed

Root	Terms	D
Gr. *acros* topmost	acromorph	G
Gr. *blastos* a sprout	blastophytic	G
Gr. *blastos* a sprout	blastopsammite	G
Gr. *blastos* a sprout	blastopsephite	G
Gr. *endo* within	endogenic	A
	endometamorphism	G
	endorheism	G
Gr. exo outside	exorheic	G
Gr. *graptos* written, *graphein* to write;	crystallography	C, O
	graphite	C
	lithograph	G
Gr. *hyalos* glass	hyaloclasic (textures)	G
	hyalophitic	G
	hyalopilitic	G
Gr. *Lithos* stone	lithium	C
	lithology	G
Gr. *ophis* snake	granulophitic	G
	subophitic	G
Gr. *pedon* ground, soil	pediplain	G
	pedocal	G
	pedology	G
	pedorelic	G
	pedosphere	G
Gr. philos friend	atmophile	G
	hydrophilic	G, C
	lithophile	G
	thiophile	C, G
Gr. *regos* a blanket,	regosol	G
Gr. *rhyx* a lava stream, *rheos* flow	endorheism	G
	exorheic	G
	rheidity	G

	rheoignimbrite	G
Gr. *sapros* rotten	saprogenous ooze	G
	sapropel	G
Gr. *sphenos* wedge,	sphene	A
	asthenosphere	G
Gr. *tachys* swift	isotach	M
	tachykardia	A
Gr. *xenos* strange	xenobiotic	B
	xenogenesis	G
	xenon	C
	xenophile	G
Gr. *zeiin* to boil	azeotrope	C

Part B: Terms deriving from (linked to) new roots in Part A terms

Gr. *theion* sulphur	thiol (group)	C
Gr. *pelos* clay, mud	pelelith	C

Gr. *sphaira* sphere
Gr. *rheos* flow
L. *pilus* hair;
Gr. *psammos* sand
Gr. *psephos* a pebble

3.4.5.2. Morphe (Table 9)

Morphe is shape in Greek; morphology is the study of external appearance (i.e., shape). In amorphous (Gr. *a* without) solids, there is a lack of crystal shape while in ideomorphic (Gr. *ideos* own, distinct) solids, the original shape retains. "Panideomorphic", is also called "panautomorphic". "Hypidiomorphic" (or hypautomorphic; Gr. *hypo* sub, under) is similar to "subhedral" (*hedra* seat). Xenomorphic (Gr. *xenos* strange, see Table) rocks have external components embedded in the crystal outline. "Allotriomorphic" (Gr. *allotrio* alien) means non-crystalline in outward form (but crystalline in internal structure). "Polymorphism" is the property of a single compound occurring in different crystal forms, e.g., calcite and aragonite in the case of $CaCO_3$. Contrarily, isomorphism is when different minerals exhibit similar shape, e.g., albite and anorthite.

Table 9: Additional reading for roots producing multiple terms of Section 3.4.5.2

Terms deriving from (linked to) roots already discussed

Root	**Terms**	**D**
Gr. *hedra* seat	anhedral	C
	octahedral	C
Gr. *hypo* sub, under	hypotension	A
Gr. *morphe* shape	cryomorphology	G
	geomorphology	G
	hydromorphology.	G
Gr. *morphe* shape	amorphous	C
	morphogenetic (region)	G
Gr. *pan*, *pantos* all	panautomorphic	G
	pangea	G
	panideomorphic	G

3.4.5.3. Meta (Table 10)

Metamorphism (Gr. *meta* after) refers to a change, in geology referring to rock shape and composition. "Meta" is often implied, e.g., kata(meta)morphism (Gr. *kata* down, see Section 1), ana(meta)morphism (Gr. *ana* up, anew) which are breakdown and building up processes respectively.

Table 10: Additional reading for roots producing multiple terms of Section 3.4.5.3

Part A: Terms deriving from (linked to) roots already discussed		
Root	**Terms**	**D**
Gr. *meta* after	metharmosis (also: metaharmosis	G
Gr. *meta* after	polymetamorphism	G
Part B: Terms deriving from (linked to) new roots in Part A terms		
Gr. *harmos* a joint fitting	harmonic (motion)	

3.4.5.4. Clase (Table 11)

Klasis is breaking in Greek; its derivatives clase, clasis, clast and clastic are common affixes of which several terms are formed. Clasts (also klasts) are produced by physical breakdown of a larger (sedimentary) rock mass by different causative agents. In phenoclasts (Gr. *phainein* to show) the fracture is seen; in anguiclast (L. *anguis* snake), the fracture is winding. A similarly meaning Greek root is *schizein* from which "schist" is derived.

Table 11: Additional reading for roots producing multiple terms of Section 3.4.5.4

Part A: Terms deriving from (linked to) roots already discussed		
Root	**Terms**	**D**
Gr. *Klasis* breaking	anemoclast	G
	anguclast	G
	atmoclast	G
	autoclastic	G
	cryptoclastic	G
	epiclastic	G
	hyaloclastic	G
	intraclast	G
	lithoclase	G
	orthoclase	G
	periclase	G
	plagioclase	G
	porphyroclastic	G
Gr. *Klasis breaking*	protointraclast	G
Part B: Terms deriving from (linked to) new roots in Part A terms		
Gr. *epi* upon	epimer	C

3.4.5.5. Oro (Table 12)

In Greek, *oroes* is mountain, giving rise to terms such as orocline, orogeny, synorogenic (Gr. *syn* together), orocratic (Gr. *kratos* strength, power), orography (Gr. *graphein* to write) and so on. In the term orotath, an orogenic belt, *tath* (dung in Greek) perhaps signifies the length-wise stretching as in the case of droppings from advancing cattle.

Table 12: Additional reading for roots producing multiple terms of Section 3.4.5.5

Part A: Terms deriving from (linked to) roots already discussed

Root	**Terms**	**D**
Gr. *chloros* green,	chlorine	C
	chlorophyll	C ,B
	chlorophyte	B
Gr. *kratos* strength, power	democracy	A
L. *placare* to appease, i.e., gentle	placable	A
Gr. *syn* together	synchronous	A
	syncline	G
	syngenetic	G
	syntectic	G
	syntexis	G
	synthem	G

3.4.5.6. Cline (Table 13)

Some terms based on “cline” were earlier given under “limnology and oceanography” (Section 4.2). In geology, examples of terms based on this affix (Gr. *klinein* to lean) are; syncline (Gr. *syn* together), geosyncline, orocline and orogeosyncline. Changing the prefix, we get more terms like aclinal, anaclinal (Gr. *ana* up, anew), pericline, diaclinal (Gr. *dia* through, across), anticline (Gr. *anti* against), anticlinorium, geanticline, and placanticline (L. *placare* to appease, i.e., gentle). The terms “triclinic” and “monoclinic” given to crystalline solids is to signify the orientation of their crystal axes. Clinochlore is green (Gr. *chloros* green). In the terms phyllofacies (Gr. *phullon* leaf) and phyllomorphic (stage), compression aided advancement to near extreme stage of the geological process is indicated.

Table 13: Additional reading for roots producing multiple terms of Section 3.4.5.6

Part A: Terms deriving from (linked to) roots already discussed

Root	**Terms**	**D**
Gr. *allos* different	allogene	G
	allophane	G
	anallobaric	M
Gr. *gennaine*, to produce	chalkogen	G, C
Gr. *keras*	keratin	G, C
	ozokerite	G
L. *petra* rock	petrograph;	G
	petrology,	G
Gr. *piezein* to press	piezoglypt;	G
Gr. *piezein* to press	piezomagnetism	P
	piezometric	P
Gr. *sapros* rotten	saprolite	G
Gr. *tekton* builder	neotectonics	G
	syntectonic	G

Part B: Terms deriving from (linked to) new roots in Part A terms

Gr. *chalkos* ore Gr. *glyptos* carved	chalcopyrite	
Gr. *neos* new, recent	Neogene	G
Gr. *ozein* to smell	ozone (which has a fishy smell	C

3.4.5.7. Gen

Gennaine, in Greek is “to produce”. This affix is adapted for use in various forms as gene, genesis, genetic/genic, genous and geny.

Hydrogen (Gr. *hydros* water) produces water, nitrogen nitre (the common name of potassium nitrate, the fertilizer) and oxygen, acids (Gr. *oxys* sharp; oxygen was originally thought to be an essential element of all acids). “Aulacogen” is from “aula” (L. *aula* courtyard, hall). “Aula” is member of a hall as distinguished from “collegian” (i.e., at a higher level). “Chalcogen” (Gr. *chalkos* ore) is ore-former. Kerogen produces wax (Gr. *keras*)), i.e., it is a petroleum (L. *petra* rock; *oleum* oil) precursor, and hence also called a petrologen. Allogene (Gr. *allos* different) is of a mineral or rock while geotectogene or simply tectogene (Gr. *tekton* builder) is of a mountain. Epeirogeny (Gr. *epi* upon) concerns the mountain’s external features, i.e., topography. Diagenesis (Gr. *dia* through), halmyrogenesis (Gr. *hals* salt; *halmyros* salty, briny) and authigenesis (Gr. *authentikos* true, original) pertain to minerals or sediments. Examples in the adjective form of genic/genetic/genous are cryogenic (Gr. *kryos* frost), endogenous (Gr. *endo* within), morphogenetic, syngenetic (also, ideogenous), piezogenic (Gr. *piezein* to press), pneumatogenic (Gr. *pneumatos* breath), saprogenous (Gr. *sapros* rotten) (ooze), and organogenic.

3.4.5.8. Chrono (Table 14)

Dendrochronology (Gr. *dendron* tree) is based on tree rings, and tephrochronology (Gr. *tephra* ashes) on volcanic ash. Orthogeochronology (Gr. *orthos* straight, correct) depends on the stratigraphically significant species while parageochronology (Gr. *para* other) depends on other accompanying species.

Table 14: Additional reading for roots producing multiple terms of Section 3.4.5.8

Part A: Terms deriving from (linked to) roots already discussed

Root	Terms	D
Gr. *dendron* tree	dendrogram	A
Gr. *orthos* straight, correct	orthoclase	G
	orthogneiss	G
	orthotectic	G
	orthotill	G
Gr. *para* other	paragenesis	G
	paragneiss	G
	paralimnion	O
	parastratotype	G
	paratill	G
	paroxysmal	G
Gr. *tephra* ashes	tephigram	G

3.5. Miscellaneous terms

In the above sections, particular attention has been given to roots yielding multiple terms. Due to (self imposed) space constraints, quite a few terms were not discussed as their roots have limited applicability or because they do not belong to any of the groups identified. These terms and their roots are given in Table 15.

Table 15: Some Additional Cross Connected Terms and their Roots (not covered in text)

	Root	Terms	D
Gr.	*amphi* on both sides; L. *ambo* both	amphibole	G
L.	*clavis* key; *clavus* nail	autoclave	A
L.	*collum* neck	pseudocol	G
L.	*cretum* to grow	concrete	A
		gypcrete	G
		salcrete	G
Gr.	*dromos* running	amphidromic	G
Gr.	*dys* bad	dysharmonic	P
Gr.	*engys* near	engysseismology	G
L.	*fugere* to flee	fugacity	C
	glacies ice	periglacial	G
Gr.	*glyptos* carved	piezoglypt	G
Gr.	*gnathos* a jaw	plectognathi	B
L.	*gypsos* gypsum, chalk		G
Gr.	*haptein* to fasten	synapsis	M
L.	*ignis* fire	igneous rock	G
L.	*imber*, *imbris* a shower of rain	ignimbrite	G
Gr.	*kephalos* head	leptocephalus	B
Ger.	*kern* a grain, nucleus	kernel	B
		steinkern	G
Gr.	*kome* hair of head	Neocomian	G
Gr.	*lepton* slender; *lepta* (plural)	leptogeosyncline	G
Gr.	*melas* black, *melan (s)*	melanine	G
L.	*nivis* snow	niveoglacial	G
Gr.	*plektos* twisted	plectoptera	B

Gr.	*psilos* bare	psilomelane	G
Gr.	*skopein* to view	microscope	B
Ger	*stein* stone	rillenstein	G
		tonstein	G
	syn together	synoptic (data)	M

Some Terms not involving cross-connection

Cel	*ceara* red	charmouthian	G
Ger	*feld* field	feldspar	G
Gr	*chasma*: chainein, to gape	rhombochasm	G
Gr	*cheír* hand	chiropody	G
		achiral	C
Gr	*chroa* color	dichroism	P
Gr	*chthonos*, soil	allochthonous	G
		autochthonous	G
Gr	*drosos* dew, moisture	drosometer	M
Gr	*floris* a flower	flora	B
Gr	*myelos* marrow	myelonite	G
Gr	*pachys* thick	isopach	M
Gr	*pachys* thick	pachyderm	B
Gr	*phreatia* cistern	phreatomagmatic	G
Gr	*spodos* ashes	spodosol	G
Gr	the letter Δ (delta)	prodelta	G
Gr	*xeros* dry	Xeralf	G
		xerography	A
Gr	*xylon* wood	xyloid (lignite)	B
Gr	*zeugon* yoked	zeugosyncline	G
		zygote	B
L	*aestus* tide	estuary	O
L	*annus* a year	perennial	A
L	*argilla*, Gr *argillos* white clay; *arges* white	argillaceous	G
L	*dextrorsum* (earlier: *dextrovorsum*) toward the right	dextral (fold)	G
L	*durus* hard	duraluminium	C
		durite,	G
		durain,	G
		durargid,	G

		duricrust	G
		duripan	G
L	*gavis* heavy	gravity	P
		gravimetry	C
L	*lingua* the tongue	lingulate,	G, O
		lingua franca	A
L	*litoris* shore	littoral	O
L	*paene* almost	peneplain	G
		peninsula (insula an island)	O
L	*quaqua* withersoever	quaquaversal	G
L	*siccus* dry	desiccation	G
L	*sinister* left, on the left side of	sinistral coiling	B,G
L	*vertere*, *versum* to turn	verse	A
L	*viridis* green	viridite	G
		vitrin	G
		vitrinite	G
L	*volcanus* God of fire	volcanogenic	G

4. Conclusion

Classical technical terms in Earth sciences derive from about three hundred Greek, followed by Latin and German word roots. More terms continue to be derived as newer concepts develop. Frequently used affixes include: *iso, lith (or lite), gen, geo, cline, morphic, hydro, ortho*, *para, thermo, clase, syn, chrono, strato, pseudo, thermo* etc. The knowledge of etymology of technical terms can possibly remove the often intimidating appearance of technical terms and help students to better understand the concepts represented. The work may also catalyze exercises which take stock of the terms with a view towards examining the relevance of some old confusing terms, and in some cases to suggest new appropriate terms that can better explain current knowledge.

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