# Examples

Some rock descriptions from geologic maps and the literature, to look at kinds of part whole relationships implied.

## GeologicUnit with three rockBodyParts

Leucogranite

Biotite granitoid

Amphibole-rich gneiss

**Mixed granitoids and amphibolite**. (Early Proterozoic). Leucogranite and biotite granitoid mixed with 10-50% amphibole-rich gneiss. Contacts are gradational with varying proportions of granitic and metamorphic components.

## GeologicUnit with three rockBodyParts,

Leucogranite

Biotite granitoid

Gneiss component--has two parts *amphibolite gneiss*, *mixed amphibolite and amphibole-plagioclase-biotite-(quartz) gneiss with concordant and discordant granitic lithosomes*; 'continuum' relation between parts

**Mixed amphibolite and granitoids**. (Early Proterozoic). Amphibole-rich gneiss mixed with 10-50% leucogranite and biotite granitoid; leucogranite generally subordinate to biotite granitoids. Gneiss component is fine-grained amphibole-plagioclase gneiss with well developed planar fabric defined by aligned amphibole and laminated compositional banding of amphibole- or plagioclase-rich layers, or locally by 1-15 cm thick quartzo-feldspathic layers. Ranges from homogeneous amphibolite gneiss to mixed amphibolite and amphibole-plagioclase-biotite-(quartz) gneiss with concordant and discordant granitic lithosomes.

## Intrusive igneous comples

Diorite mostly; massive to weakly foliated

Some gabbro

Some granodiorite. locally granodiorite is porphyritic, some porphyritic granodiorite is megacrystic (relation to other geologic unit: 'similar')

Locally metamorphosed to semi schist

Locally Leucogranite irregular intrusions (relation-leucogranite cuts foliation in diorite)

JYd mafic to intermediate intrusive rocks-- mostly medium-fine grained, texturally variable diorite, locally ranges from *gabbro(?) to granodiorite*. Equigranular, granodioritic zones *locally porphyritic*. Rare megacrystic phases contain 2-5 cm blocky, equant K-feldspar in fine-grained recrystallized groundmass biotite- plagioclase-epidote+quartz and resemble Sore Fingers monzodiorite of the northern Little Harquahala Mountains. Metamorphosed to biotite-plagioclase +quartz semi-schist in S Mountain area. Irregularly intruded by leucogranite northwest of Campbell house claims; foliation in diorite in this area is truncated by the leucogranite. Unfoliated to weakly foliated.

## Gneiss complex

Quartzo feldspathic gneiss

Mafic gneiss (continuum relation to quartzo-feldspathic gneiss)

Leucogranite injections (form not described) (relation- cut foliation in gneiss) (dissective—not localized in description)

Local—lenses of highly deformed medium-grained equigranular biotite granitoid (non dissective—only present in one area)

Various fabrics: pencils, planar, contorted (non dissective—only one style in a given area)

Tenahatchipi gneiss-- heterogeneous, fine-grained, quartzo-feldspathic to mafic gneiss. Quartz-feldspar- muscovite-biotite gneiss with 2-20 cm banding defined by mineralogical and textural variations, especially biotite concentrations; abundant leucogranite injections are discordant to subconcordant to this fabric. A superimposed schistosity related to the Centennial thrust in the outcrops northwest of Tenahatchipi Pass results in 'pencil' weathering. Interleaved with augen gneiss over 10-20 m at the contact. On top of Twin peaks contains lenses of highly deformed medium-grained equigranular biotite granitoid. Foliation is highly contorted on northern side of Twin Peaks but becomes more planar and regular to south. Folding of foliation may be result deformation associate with Centennial thrust which is nearly parallel with the north slope of Twin Peaks.

## Tuff, Two (or three?) rock body parts

Dacite tuff

Basal densely welded zone. (non dissective part)

Lithic fragments – felsite (dissective part, or part of rock material?)

**Welded tuff**. (Miocene) Brown weathering dacite(?) tuff containing 5-7% 1 mm crystals of hornblende and plagioclase, with sparse biotite, and trace amounts of quartz and pyroxene. At base is a dark brown porcelaneous densely welded zone. Fiamme are black and glassy in densely welded zone, and light brown (lighter than matrix) in overlying welded tuff; they are generally small (3-5 cm long, ~ 1 cm thick). Lithic fragments compose about 5% of rock, and consist of dark to light grey and red-brown felsite.

## Multiple Facies

Facies (non dissective) 1) granite-quartzite (Cb) cobble, blocks in east part of area, 2) Redwall (Mr) and Martin (Dm) formation blocks predominant in west; 3) large blocks or sheets of Dm, Mr and Cb separated by thin lenses of calcareous lithic sandstone (SW of Apache Chief mine)

local angular clast conglomerate derived from JKc

Blocks – correlate with Bolsa Quartzite, Poorman Granite, Redwall Limestone, Martin Formation (dissective part)

Matrix—arkose grit (dissective in facies 1, 2), calcareous lithic ss, some Thin limestone beds with algal structures in facies 3.

**Megablock conglomerate and breccia**--blocks of Paleozoic and Proterozoic rock up to about 50 m in long dimension enclosed in a matrix of lithofeldspathic to arkosic sandstone and conglomerate. Two types have been observed: 1) granitoid and quartzite cobble conglomerate type present in a zone below the Poorman thrust in the eastern part of the map area; consists of 1-50 m long blocks which appear to be internally coherent (locally depositional contacts between quartzite and granite are preserved) thin sheets with a sandstone and conglomeratic sandstone matrix. Depositional contacts between sandstone matrix are locally preserved, indicating that the mixing of the blocks in the sandstone is primary. The matrix is an arkosic grit apparently consisting largely of disaggregated Proterozoic granitoid (Yg). In outcrops east of Apache Wash the blocks become mostly Redwall and Martin Formation westward towards the wash. The unit apparently grades into sandstone (Ks) or sandstone and conglomerate (Ksc) to the east both in the Poorman Mine area and in the southeastern part of the map. The contact with Crystal Hill formation (JKc) in the southeastern part of the map is interpreted to be depositional; an interval of bleached JKc, and local angular clast conglomerated derived from JKc is present along the contact. This contact might be a fault. Whatever its nature, it pre-dates the formation of cleavage in rocks adjacent to the contact. 2) The second megablock conglomerate type is present in a thin interval between the chaos unit (JKch) and conglomerate SW of the Apache Chief mine. This unit contains much less matrix, and consists of large blocks or sheets of Dm, Mr and Cb separated by thin lenses of calcareous lithic sandstone. Thin limestone beds with algal structures are rarely present in these sandstones.

## Dissective rock body parts

RockBodyPart: coarser-grained intervals more abundant conglomeratic sandstone

RockBodyPart: finer-grained intervals more abundant siltstone, mudstone and interbedded oncolitic limestone (interbedded relation with coarser intervals)

RockBodyPart: fining-upward sequences; each sequence is a dissective rock body part; local area where they occur is non-dissective rock body part

RockBodyPart: Scattered beds of porcelaneous argillite or fine-grained sandstone (dissective part) become more common *up section as the contact with unit JKp is approached* – nondissective part.

**Sandstone**. (Cretaceous or Jurassic) Mostly fine to coarse grained, brown weathering, thin to medium bedded lithofeldspathic sandstone, with siltstone or mudstone partings. Interbedded coarser-grained intervals, with **more abundant conglomeratic sandstone**, or finer-grained intervals with more abundant siltstone, mudstone and interbedded oncolitic limestone are present throughout the section. In the lower part of the section just north of Black Mesa, a series of fining upward sequences, from conglomerate through sandstone to mudstone with sparse interbedded oncolitic limestone is present, capped by a massive conglomerate (unit JKc). Conglomerate beds locally contain clasts up to 20 cm in diameter; clast types include Paleozoic limestone, Jurassic(?) quartz-feldspar porphyry, a distinctive Jurassic(?) hypabyssal porphyry with 1 cm diameter blocky K-feldspar phenocrysts, and rare weakly foliated medium fine-grained biotite granitoid. In finer grained intervals, series of graded beds are occasionally observed. Aligned tool marks are observed on the upward facing base of sandstone beds in many places. Fossil hash (plant material?) is locally present in fine-grained units. Scattered beds of porcelaneous argillite or fine-grained sandstone become more common up section as the contact with unit JKp is approached…. This unit grades into volcanic-clast conglomerate along a poorly exposed contact at its base, and grades into unit JKp at the top.

## Melange

Melange unit type

Metagraywacke unit type

Metavolcanic unit type

Sedimentary Breccia type

Shale matrix angular metagraywacke, metavolcanic, and metachert clasts

Sandstone matrix ? metavolcanic clasts with subordinate metagraywacke and metashale clasts?

Clast supported -- metavolcanic clasts with subordinate metagraywacke and metashale clasts

Non foliated

strongly foliated with appearance of scaly mélange

High-grade block type (in mélange, possibly in sedimentary breccia) amphibolite, garnet-amphibolite, and eclogite

Serpentinite body

Aragonite veins (in sedimentary breccia)

These are all rockBodyParts that ?should be considered dissective because within the detail of the description, any could show up in any part of the unit.

**Franciscan Formation (**from Wakabayashi, 2011 GSA SP480, abundantly edited to separate description and interpretation, also remove some metamorphic mineral info to simplify) **--** In the Sunol Regional Wilderness area of the northern Diablo Range, mélange zones separate and cut coherent metagraywacke and metavolcanic units of blueschist facies. Most mélanges .. have sedimentary breccia associated with them…. …. Most of the breccias are shale-matrix supported with angular metagraywacke, metavolcanic, and metachert clasts. Sandstone-matrix breccias also occur, as do clast-supported breccias, consisting mainly of metavolcanic clasts with subordinate metagraywacke and metashale clasts. …The breccias show a textural gradation from nearly undeformed breccia to strongly foliated material that takes on the appearance of scaly mélange. Clast size ranges from centimeters to an observed size of at least 7 m.

Much larger blocks (up to hundred meter scale or larger) crop out in the area, but the block-matrix relationships are not exposed. The proximity of larger blocks to breccia localities, …, suggests that the breccia may include blocks of such size.

Aragonite veins crosscut the breccia …. The surrounding coherent units or large blocks... all exhibit blueschist-facies assemblages with the most common lithology, graywacke, containing neoblastic lawsonite, glaucophane, and jadeitic clinopyroxene. …

Higher grade metamorphic material is present in scattered clasts [?in sedimentary breccia?] as large as 1 m in diameter…. these … exhibit similar metamorphic grain size and overprinting relationships ] as the high-grade blocks.

In addition …, high-grade blocks occur in mélanges in the Sunol Regional Wilderness area, …. The high-grade blocks include amphibolite, garnet-amphibolite, and eclogite up to 10 m in exposed long dimension. Most of the blocks found occur on the boundaries of shale matrix mélange or on the boundaries of serpentinite bodies. In contrast, the smaller high-grade breccia clasts (nearly all <1 m in size) found in the W-Tree Scramble transect do not appear to be localized along the border of the unit.…

Serpentinite clasts are locally common in the breccia as well.

## Simple Group-Formation parts

Supai Group

* Watahomigi Formation
* Manakacha Formation
* Wescogame Formation
* Esplanade Sandstone

4 parts of the Group, each a Formation. Non dissective—not every part of the Supai group includes all four parts.

# Logic

RockBody hasPart only (RockBody)

**PROBLEM:: GeologicMaterial is subclass under RockBody, so a GeologicMaterial could have a GeologicUnit as a part. This does not make sense. The various subclasses have to restrict the subtypes of RockBody that make sense as parts.**

GeologicUnit is abstract (no instances). If formal or informal stratigraphic nomenclature is established, describe RockBody as a kind of GeologicUnit

SuperGroup hasPart only (RockBodyPart OR Group)

Group hasPart only Formation

Formation hasPart only (RockBodyPart OR Member)

Member hasPart only (RockBodyPart OR Bed)

RockBodyPart hasPart only RockBodyPart

GeologicUnit hasConstituent only RockMaterial OR RockBodyConstituent

RockBodyPart hasConstituent only RockMaterial OR RockBodyConstituent

RockBodyConstituent hasConstituent only RockMaterial OR RockBodyConstituent

RockMaterial hasConstituent only (GranularMaterial OR Mineral OR Element or Glass)

GranularMaterial hasConstituent only (RockMaterial OR Mineral or Element or Glass) (have to allow rockMaterial to describe e.g. rhyolite(RockMaterial) clasts (GranularMaterial) in Conglomerate(RockMaterial composed of granularMaterial.clasts)

Mineral hasConstituent only Element