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DEPARTMENT OF GEOLOGY

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PROVENANCE

The term provenance comes from the French term "*Provenier*" which means 'to originate or to come from'. The source area and the source rock of a sediment and also according to some authors the relief, climate and environment prevailing at the source are collectively called as its provenance.

The transportation process by agents such as gravity, water, wind or glacier breaks rocks into smaller particles by physical abrasion, from big boulder size into sand or even clay size. At the same time minerals within the sediment can also be changed chemically, only minerals that are more resistant to chemical weathering can survive (e.g. ultrastable minerals zircon, tourmaline and rutile). During the transportation, minerals can be sorted by their density, and as a result, light minerals like quartz and mica can be moved faster and further than heavy minerals (like zircon and tourmaline).

After a certain distance of transportation, detritus reaches a sedimentary basin and accumulates in one place. With the accumulation of sediments, sediments are buried to a deeper level and go through diagenesis, which turns sediments into sedimentary rocks (i.e. conglomerate, sandstone, mudrocks, limestone etc.) and some further form metamorphic rocks (such as quartzite) which were derived from sedimentary rocks. After sediments are weathered and eroded from mountain belts, they can be carried by stream and deposited along rivers as river sands. Detritus can also be transported and deposited in foreland basins and at offshore fans. The detrital record can be collected from all these places and can be used in provenance studies.

Thus, sedimentary rocks are an important source of information about previous orogenic conditions and the composition of which may describe the evolution of provenance and tectonic setting. As the sediment composition changes through time, the geochemical characteristics of the sediment can be used to understand its geologic history. The purpose of provenance study is to restore the tectonic, paleo-geographic and paleo-climatic history.

Quartz, feldspar and heavy minerals are particularly used to decipher provenance.

Quartz, feldspar and heavy minerals as provenance indictors

Quartz is the most abundant detrital constituent of sedimentary rocks and it survives prolonged weathering as it is very stable. It has been believed that distict characteristics such as undulatory extinction ('strain shadows') and polycrystalline nature in quartz grains are indicative of metamorphic source rocks whereas plutonic/volcanic rocks are devoid of these features (Basu, 1985).

The Indiana group developed a method of discriminating sedimentary rocks of plutonic, low or high rank metamorphic parentage by plotting the proportions of following parameters on a 'Diamond Diagram'- undulatory quartz , polycrystalline quartz, non-undulatory quartz and the number of crystal units per polycrystalline grains of quartz (Figure-1).

Feldspar is the next abundant detrital constituent of sedimentary rocks and can also be used for provenance studies. Homogeneous alkali feldspars more sodic than Ab_{50} are generally of volcanic origin whereas feldspars more potassic than Or_{88} indicate metamorphic and plutonic source rocks (Trevena and Nash, 1981). Detrital feldspars from metamorphic source rocks are generally microcline and those from volcanic source rocks is usually sanidine.

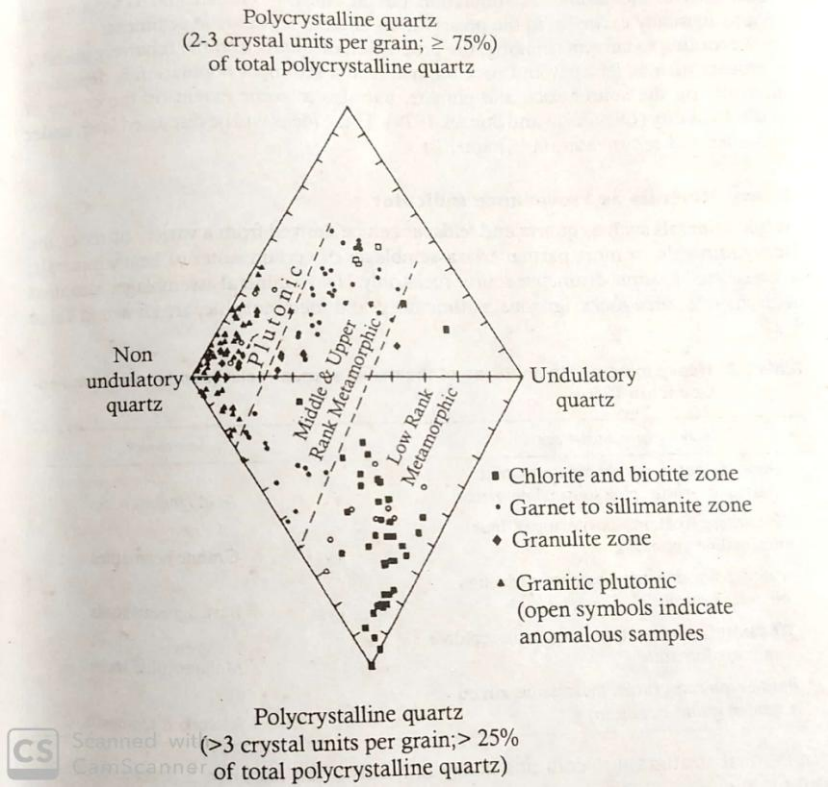

Figure 1- Diamond diagram showing different varieties of quartz grains from plutonic igneous and metamorphic sources (Basu et al., 1975).

Minerals that have specific gravity greater than 2.9 are called heavy minerals. These minerals include both chemically stable and unstable varieties. The most stable heavy minerals such as tourmaline, zircon, and rutile, whereas much less stable minerals, epidote, zoisite, chamosite and hornblende etc. While quartz and feldspars can be derived from a variety of sources, the heavy minerals (or their assemblages) are restricted to distinctive source rocks only (Figure 2).

Figure-2- Heavy mineral assemblages of major source rocks (modified after Feo-Codecido,1956)

Association	*Source*
Apatite, biotite, brookite, hornblende, monazite, muscovite, rutile, titanite, tourmaline (pink variety), zircon	Acid igneous rocks
Cassiterite, dumortierite, fluorite, garnet, monazite, muscovite, topaz, tourmaline (blue variety), wolframite, xenotime	Granite pegmatites
Augite, chromite, diopside, hypersthene, ilmenite, magnetite, olivine, picotite, pleonaste	Basic igneous rocks
Andalusite, chondrodite, corundum, garnet, phlogopite, staurolite, topaz, vesuvianite, wollastonite, zoisite	Contact metamorphic rocks
Andalusite, chloritoid, epidote, garnet, glaucophane, kyanite, sillimanite, staurolite, titanite, zoisite-clinozoisite	Dynamothermal metamorphic rocks
Barite, iron ores, leucoxene, rutile, tourmaline (rounded grains), zircon (rounded grains)	Reworked sediments