# CHAPTER 3

# PETROGRAPHY OF SANDSTONES

## 3.1 General statement

Attempts at interpretation of sediments are strongly directed toward reconstruction of the environment during deposition at a particular time and place. General steps of techniques of the sandstone provenance studies conceptually fall into three approaches. Basically, the first approach is the detailed stratigraphic studies and field mapping on the sandstones and their related strata. The second is more advance approach, involving characterization of the bulk composition of the sandstones. This approach is systematically performed by the point-count determination of modes on detrital framework grains (Dickinson and Suczex, 1979; Dickinson et al., 1983; Dickinson, 1985; Lash, 1985). Lastly, the third approach is to quantifying characteristics of a single-mineral analysis to increase confidence in provenance interpretation and simultaneously to add the details unavailable from the first and second approaches (Basu et al., 1975; Trevana and Nash, 1981; Cookenboo et al., 1997; Chutakositnon, 1999; Chutakositkanon et al., 2001b).

Regarding the field investigation, the Pong Nam Ron Formation includes generally a turbidite succession of sandstones and shales, with sometimes conglomerates. Frequently sandstone layers show typical sole marks as load casts, flute casts, and groove casts. Within the sandstone beds, the strata have sharp abrupt bases, and tend to grade upward into finer sand-, silt- and clay-sized. Some sequences display an almost complete Bouma sequence.

Based upon the tectono-stratigraphy of the SKCB-AC, it is presumed that the Pong Nam Ron Formation was formed as the Middle Triassic covering sediment on the Permo-Triassic mélanges. Furthermore, many detrital chromian spinels were discovered from these turbiditic sandstones of the Pong Nam Ron Formation (Chutakositkanon et al., 2001a, 2002, 2003a, 2003b). Therefore, the petrography of spinel-bearing sandstones of the Pong Nam Ron Formation is useful for understanding the characteristics and provenance of the mélange covering sediments and especially for understanding the sedimentary environments when detrital chromian spinels were deposited.

3.2 Petrography of sandstones

In the thin-section investigation, greenish gray to dark gray turbiditic sandstones of the Pong Nam Ron Formation are fine- to very fine-grained greywacke (Plates 9 to 15). They are generally alternated with black shale. Petrographically, the greywackes are systematically analyzed by the point-count determination of modes on detrital framework grains for the bulk composition of sandstones of the Pong Nam Ron Formation. All of greywackes belong to the class "feldspathic greywacke and lithic greywacke" of Folk (1974) (Fig. 37). The rock fragments of gneiss and schist with the foliation textures are very common and easily recognized in some thin sections. The recognized

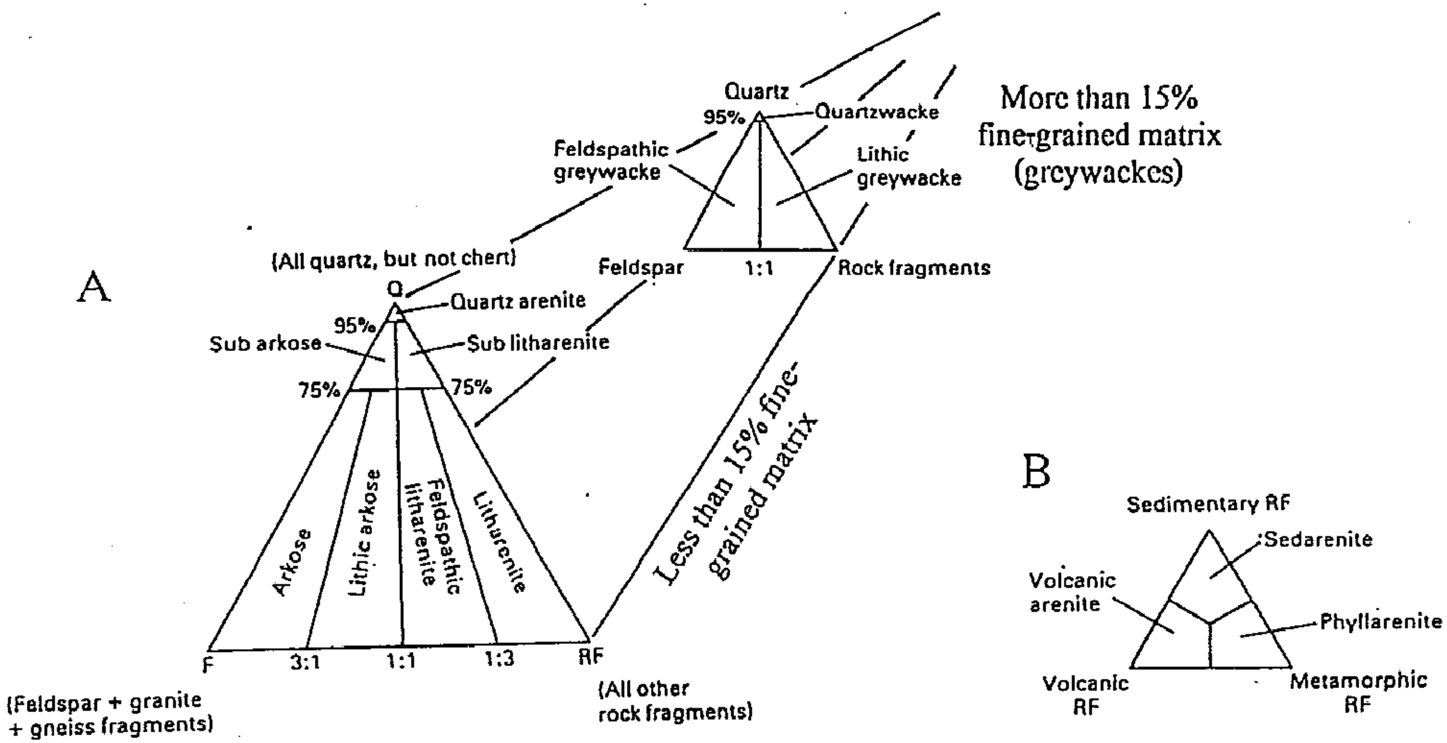


Fig. 37 Diagram of sandstone classification (after Folk, 1974).

fossils are bryozoa and calcareous algae. All the lithic greywackes are fine- to very fine-grained sandstones. Poorly sorting and immature stage (Folk, 1951) can be observed in these lithic greywackes. The characteristic of particle roundness is angular to sub-rounded but mainly angular.

A lot of detrital chromian spinels are discovered in the sandstones of this covering Pong Nam Ron Formation. The detrital spinels occur as an accessory mineral in matrix (less than 1%). However, the presence of detrital chromian spinels in one thin section attains to about 7 to 10 grains. Generally detrital chromian spinels display reddish brown to deep brown or black and range from 20 μm to 400 μm in size. Several grains exhibit sub-hedral to euhedral suggesting the preservation of original crystal shape and contain inclusions. It is valuable to note that these characteristics are similar with chromian spinels that have been formed in the volcanic origin as described in Arai (1992).

3.3 Interpreting the provenance of sandstones

Detrital composition modes of sandstones primarily reflect on their different tectonic settings, although other various sedimentological factors also influence sandstone compositions. Comparisons of sandstone compositions are systemically displayed on standard triangular diagrams by grouping diverse grain types into a few operational categories having broad genetic significance, such as the compositional fields associated with different provenances of Dickinson and Suczek (1979), Dickinson et al. (1983), and Dickinson (1985) (Fig. 38).

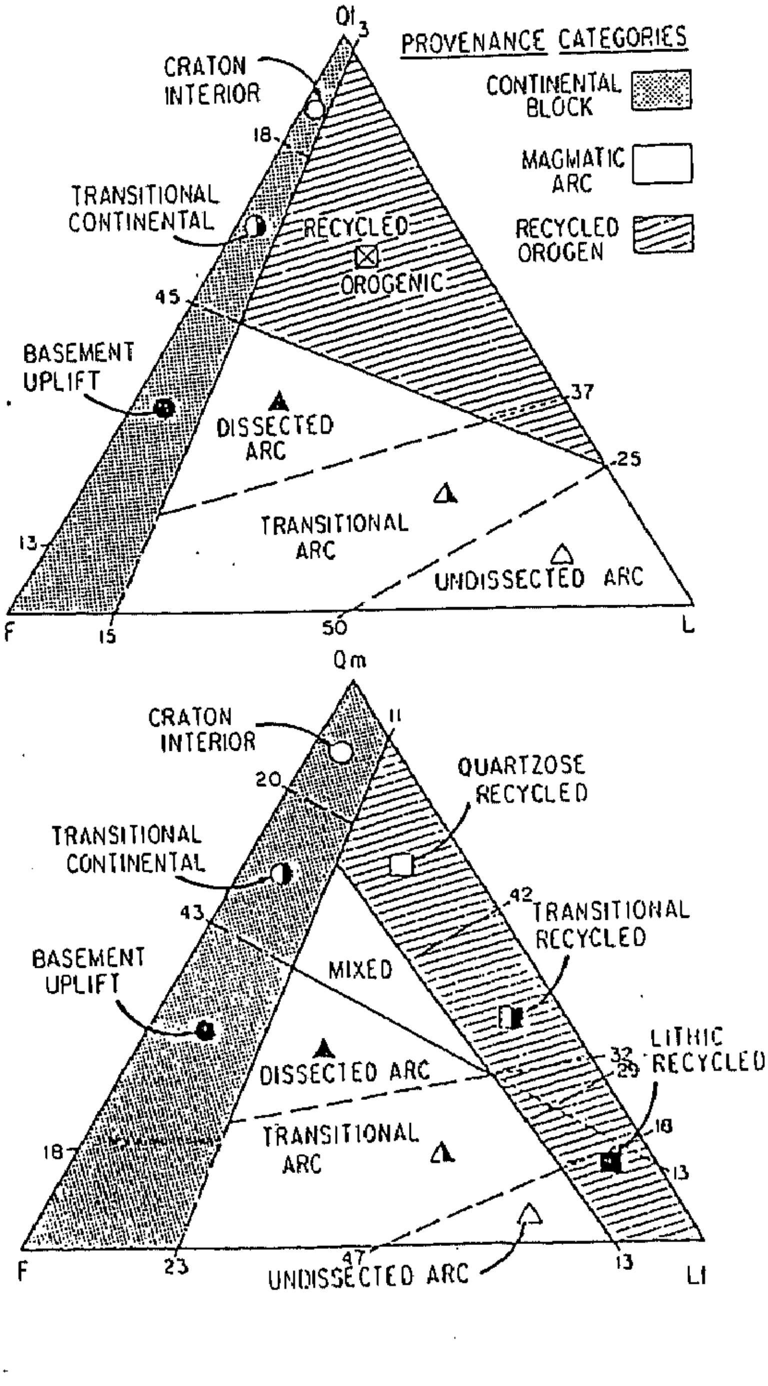


Fig. 38 Standard triangular diagrams of Dickinson et al. (1983).

### 3.3.1 Sample preparation - Sampling and analytical techniques

Thin sections of turbiditic sandstones from the Pong Nam Ron Formation are systematically preformed for the point-count determination of modes on detrital framework grains. The discrimination between quartz and potassium feldspar under the microscope, however, is very difficult in some cases. To deal with the evaluation of these thin sections of sandstones using a systematic procedure called modal analysis, it needs to be identified quickly and accurately. The only reliable and quick way to differentiate between quartz and potassium feldspar (K-feldspar) is to stain them with sodium cobaltnitrate solution.

Thin sections for the point-count determination of modes on detrital framework grains were prepared as similar as that for normal thin sections in the early stages. The rock slices were ground to final required thickness about 30 μm, before starting the staining for the potassium feldspar (Orthoclase, $KAlSi_3O_8$) in the next step. Half of the rock surfaces of thin section were covered by plastic tape for keeping the original surface from the etching of hydrofluoric acid (HF) and the staining.

Next, these half-covered thin sections were etched over the HF vapor (55% HF solution) for 25-35 seconds, and then removed the slide from the etching box and dropped into beaker with saturated sodium cobaltnitrate solution (about 50 grams per 100 ml of the distilled water) for 45 seconds. After that, the slides of thin sections were rinsed in the distilled water, and then blotted or aired dry. After the staining procedure with uncovered surfaces of thin sections, quartz remains unstained, while orthoclase or K-feldspar takes the yellow color from sodium cobaltnitrate.

The use of quantitative detrital modes of the sandstones, calculated from the point counts of thin sections, to infer their provenances is well established by Dickinson and Suczek (1979). The tectonic setting of the provenance apparently exerts primary control on sandstone compositions (Dickinson et al., 1983). It is a universal practice to describe monocrystalline particles as mineral grains and polycrystalline particles as lithic or rock fragments. However, there are two methodological approaches to the treatment of rock fragments during the point counting (Zuffa, 1980; Ingersoll et al., 1984). On the first hand, all parts of all polycrystalline particles can be counted as lithic fragments. On the other hand, the single crystals larger than the size of matrix limit (0.0625 mm) are then counted as mineral grains, regardless of whether they actually occur as separate clastic particles or as constituent crystals within polycrystalline particles, according to the method of Dickinson (1985).

3.3.2 Results - Modes on detrital framework grains

Twelve thin sections of turbiditic sandstones from the Pong Nam Ron Formation are selected from the sandstones along the Highway 317 (Sa Kaeo-Chanthaburi, km 29 to km 46) for the point-count determination of modes on detrital framework grains based on works of Dickinson (1985). Detrital framework grains are analyzed systematically about 500 points per each thin section for the precise compositions of sandstones. At each point, the grain size is measured and its lithology is determined.

Detrital modes are recalculated to 100 per cent as the sum of monocrystalline quartz (Qm), polycrystalline quartz (Qp), plagioclase grains (P), K-feldspar (K), volcanic/metavolcanic lithic fragments (Lv), and sedimentary/metasedimentary lithic fragment (Ls). Intrabasinal grains and the occurrence of heavey mineral are ignored, regarding the Dickinson (1985). The total quartzose grains (Qt) are the sum of Qm and Qp, while the total feldspar grains (F) are the sum of P and K. The total unstable lithic fragments (L) are the sum of Lv and Ls, while the total lithic fragments (Lt) are the sum of L and Qp.

The modes on detrital framework grains of the Pong Nam Ron Formation are carefully recalculated (see Appendix A). Characteristically the detrital frameworks of the compositions of the Pong Nam Ron Formation are high contents of averaged 38.9% Qm (ranging from 33.4% to 46.1%) and averaged 34.5% P (ranging from 26.3% to 43.2%). The contents of Qp and K are much lower about 4.0% and 2.0%, respectively. Considering the unstable lithic fragments, Lv ranges widely from 2.4% to 17.8% and averages about 11.0%, while Ls varies from 4.3% to 14.1% and averages about 9.8%.

To compare with other sandstones, the characteristics of the compositional framework of sandstones of the Pong Nam Ron Formation are shown on two triangular diagrams of Dickinson (1985); the QtFL triangular diagram with an emphasis on maturity and the QmFLt triangular diagram with an emphasis on source rocks. The plots of the compositional framework of the Pong Nam Ron Formation are mostly filled in the dissected arc in both QtFL and QmFLt diagrams (Figs. 39 and 40).

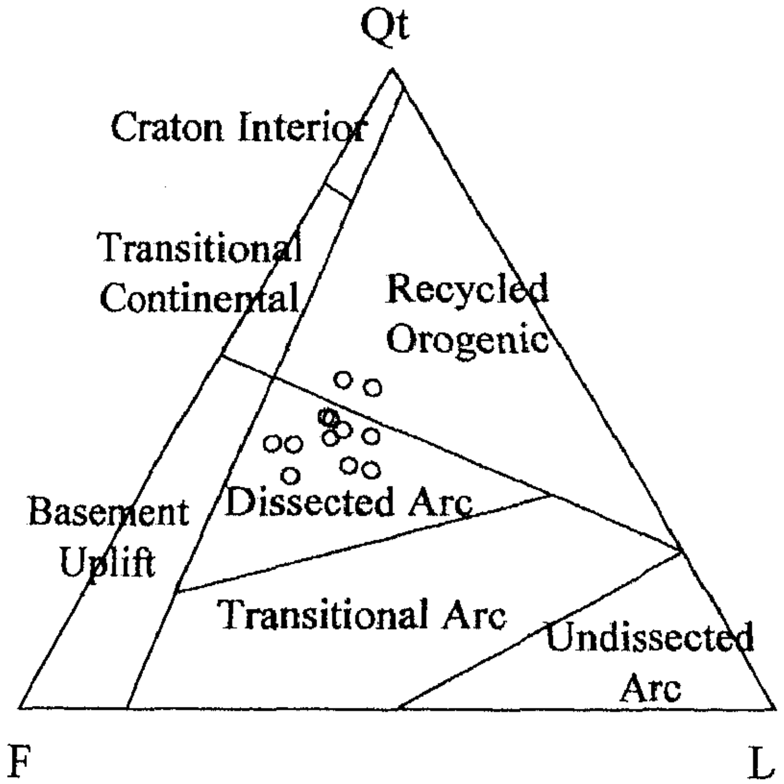


Fig. 39 The plots of turbiditic sandstones of the Pong Nam Ron Formation on the triangular QtFL diagram of Dickinson (1985).

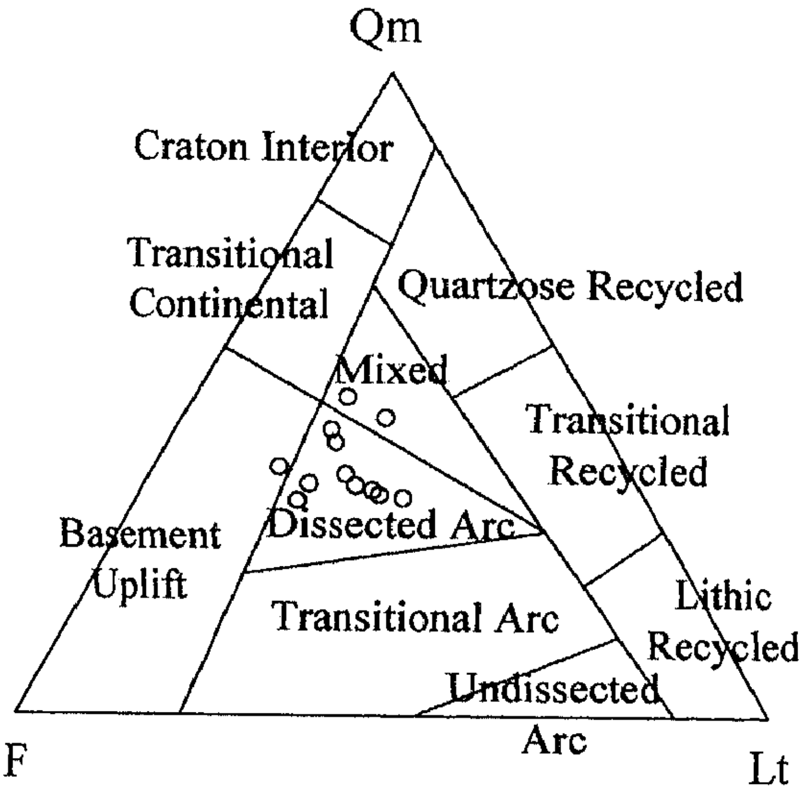


Fig. 40 The plots of turbiditic sandstones of the Pong Nam Ron Formation on the triangular QmFLt diagram of Dickinson (1985).

3.4 Characteristics of conglomerate blocks in the Ban Nong Bon unit

Characteristics of mélanges recognized in the Bon Nong Bon unit are a critical key to discriminate itself from the turbiditic sandstone and shale alternation of the Pong Nam Ron Formation. Conglomerate is a dominant rock type of tectonic blocks of the Ban Nong Bon unit. Conglomerates in the Ban Nong Bon unit are distributed in several places. They occur as outcrop sized mélange blocks in shale matrix or hill sized exposures. The hill-sized exposures of conglomerates at Khao Sa Taeng are composed of various kinds of well-rounded rock clasts (ranging 1 to 15 cm in diameter) in a greenish gray sandstone matrix. Almost rock clasts are various colored cherts, quartz, porphyritic to aphanitic volcanic rocks, fine- to medium-grained plutonic rock, metamorphic rocks and limestone.

The conglomerate blocks in mélange at the south of Ban Nong Bon are relatively finer-grained. They comprise mainly various colored cherts, basaltic rocks and limestone with subordinate sandstone and shale. About 113 clasts are collected from these conglomerate blocks for laboratory investigation of the clast population of conglomerate. The conglomerate clasts are mostly varying from 1 cm to 4 cm in size, but some of them can rise to 8 cm. With the systematic classes (Powers, 1989) (Fig. 41), the conglomerate clasts are sub-rounded to well-rounded with the average of roundness index about 3.57 and spherical to sub-prismoidal with the averaged sphericity index about 2.83. The major lithic clasts of these conglomerate blocks are various colored cherts, basaltic rocks, sandstones and limestones. Chert occupies the biggest part about 67% of clast

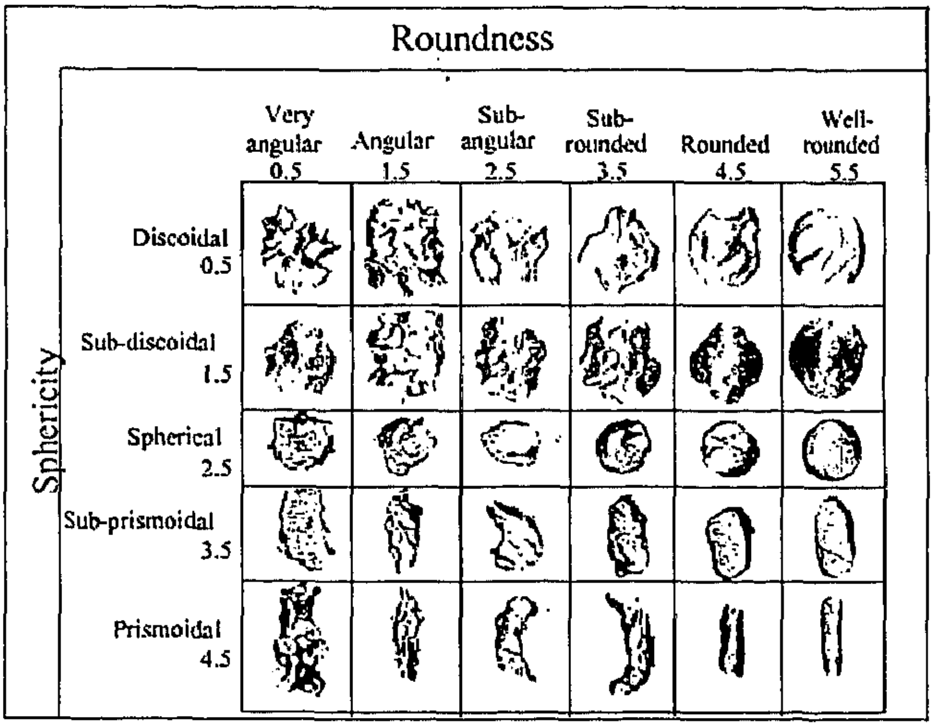


Fig. 41 Roundness and sphericity classes of the AGI (American Geological Institute) Data Sheets (Powers, 1989).

population. Basaltic rocks, sandstones and limestone are 20%, 13% and 9%, respectively (Fig. 42).

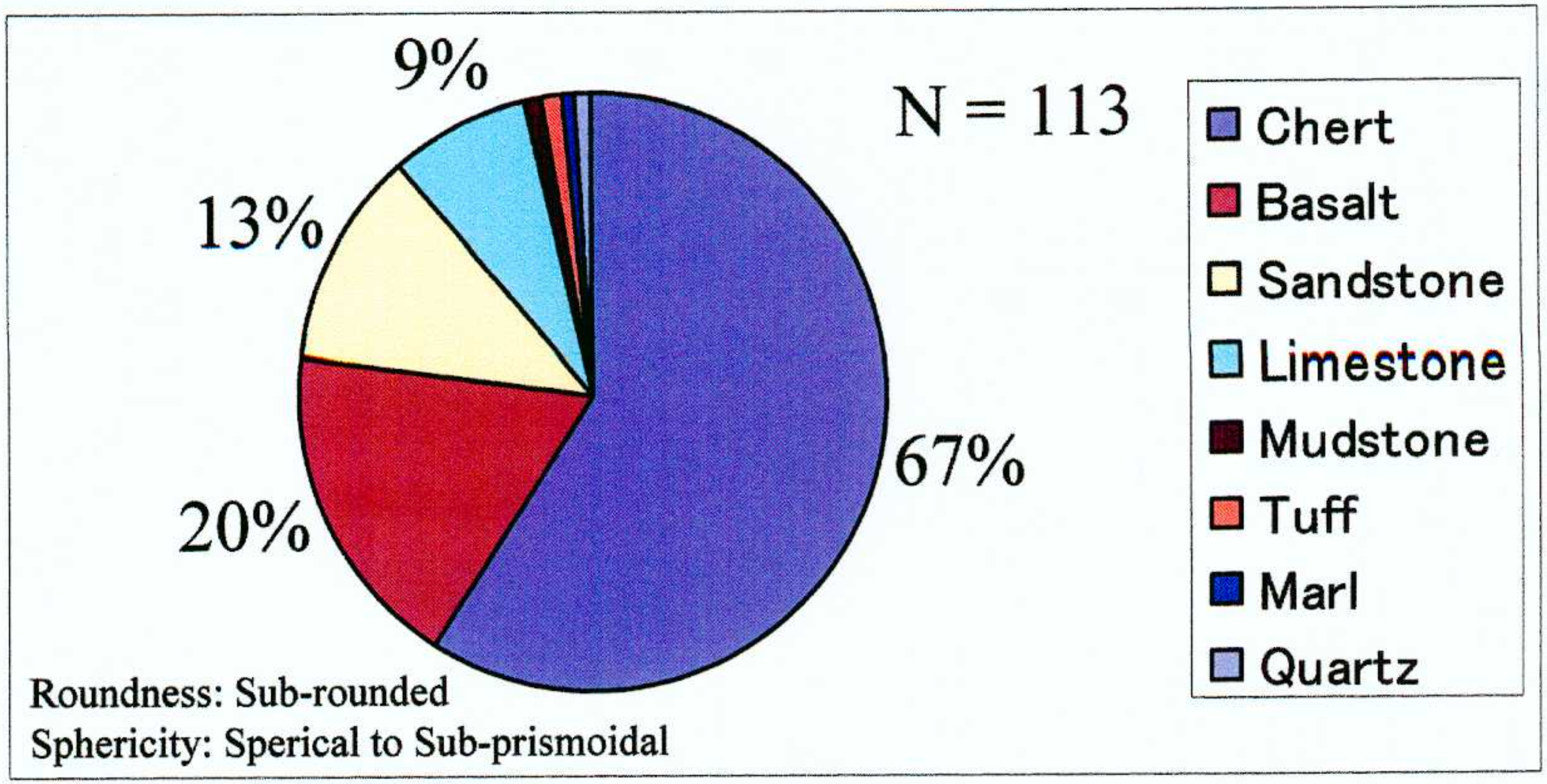


Fig. 42 Clast population in conglomerate block in mélange of the Ban Nong Bon unit.