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An introduction to sand and gravel deposit models, Front Range Urban Corridor

by

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DEFINITION

Sand and gravel deposit models are descriptions of deposits that may be mined for natural aggregate. Commonly, a mineral deposit model consists of a systematic arrangement of information that summarizes the features of a group of similar deposits (Cox and others, 1986). Deposits in each group are thought to have formed in more or less the same manner and to share similar features. The information in a model is descriptive, but judging the significance of information may depend on an understanding of how the deposit formed. By comparing features specified by mineral deposit models with the characteristics of an area of interest, models can be used to explore for mineral deposits and assess potential for undiscovered deposits.

Deposit models commonly contain summaries of information about 1) geologic environment, 2) deposit characteristics, 3) deposit size, and 4) possible environmental effects of mining. For sand and gravel deposits, the geologic environment (1) refers to the present geologic setting, which is the product of both the sedimentary environment in which the deposit formed (Langer, 1988; Smith and Collis 1993, p. 16-30) and the subsequent geologic history of the site of the deposit. Deposit characteristics (2) include information on physical properties such as sedimentary features and information that is relevant to aggregate quality or suitability, such as particle size and composition. Deposit size (3) is measured in areal extent, thickness, and volume of gravel in entire geologic units such as alluvial terraces along streams (Bliss, 1993). Environmental effects of mining (4) may be described in terms that take into account the size of the area affected, mining methods, overburden, depth to water table, and production of fine-grained waste.

EXAMPLES OF MODELS

Models of sand and gravel deposits in the Front Range urban corridor are named for their physiographic setting or mode of formation (Figure 1). The models represent a variety of geologic environments that combine a history of erosion by streams, deposition of sand and gravel and, commonly, renewed erosion. The resulting deposits have characteristic landforms such as dissected alluvial fans and river terraces at various levels. In the case of eolian sand, the model is characterized by sand and silt deposited as dunes on upland areas during periods of aridity; at present, the dunes have been stabilized by vegetation.

A working classification of sand and gravel deposit models (Table 1) of the Front Range urban corridor was compiled from previous research. Researchers for the Front Range Infrastructure Resource Project will revise the classification and description of models as more

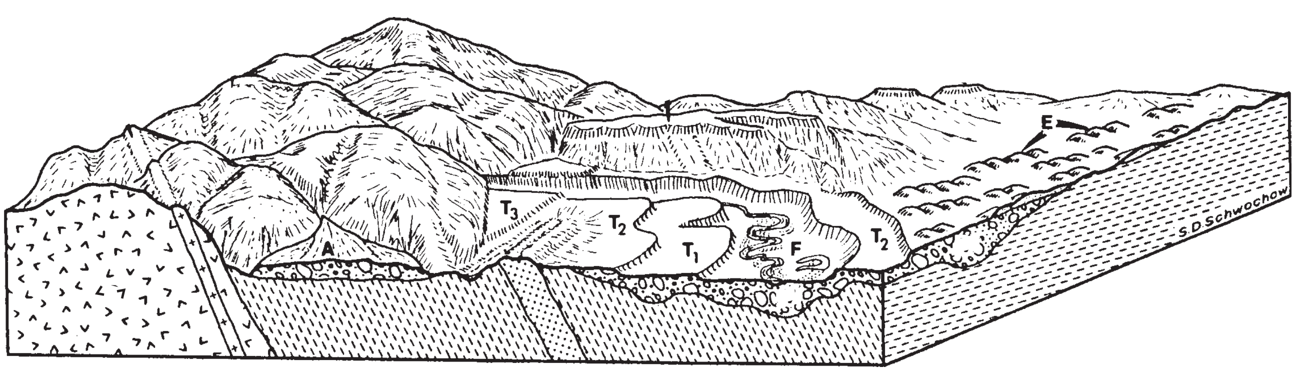

Figure 1.--Block diagram showing geologic environments and landforms associated with sand and gravel deposits of the Front Range urban corridor, Colorado (from Schwochow and others, 1974a). A, alluvial fan; T_1-T_3, high terraces; F, low terrace; E, eolian sand.

Table 1.—Sand and gravel deposit models, Front Range Urban Corridor, Colorado (compiled from Schwochow and others, 1974a;b; Colton and Fitch, 1974; and Trimble and Fitch, 1974a;b)

MODEL NAME	GEOLOGIC ENVIRONMENT	DEPOSIT CHARACTERISTICS	DEPOSIT SIZE	ENVIRONMENTAL EFFECTS
Dissected fan	Upland alluvial fan, now an interfluvial surface	Massive debris- and stream-flow deposits; low quality: poorly sorted, weathered	Small to large	?
High dissected terrace	Eroded alluvial fill; now an interfluvial surface	Channel gravel; low quality: well-sorted, weathered	Small	Small excavations
High terrace	Alluvial fill; surface above stream level	Channel gravel; high quality: graded sorting, weakly weathered	Large	Large excavations
Low terrace	Alluvial fill; surface near stream level	Channel gravel; high quality: graded sorting, unweathered	Large	Large excavations at stream level
Eolian sand	Upland dune field; stabilized by vegetation	Sand and silt; sand suitable for specialty uses; uniform particle size	Variable	Possible erosion of disturbed area

complete information is collected on deposit characteristics, size, and possible environmental effects of mining.

PREPARATION OF MODELS

The working classification of sand and gravel deposit models for the Front Range Urban Corridor is based on preliminary analysis of three kinds of available data: 1) deposit maps showing distribution of sand- and gravelbearing units, 2) subsurface sections, based on borehole logs showing depth and thickness of sand, gravel and other sediment, and 3) compilations of particle size and composition, which are useful for assessing aggregate quality or suitability. From these data, the geologic environment can be identified and deposits classified into the appropriate model for description. Deposit characteristics can be identified by integrating data on particle size and composition with maps and subsurface sections. Statistical models of deposit size can be prepared from dimensions of individual deposits shown on maps and cross-sections. Environmental effects of mining can be assessed from available maps and information on deposits as well as from direct observation of mining operations.

DATA FOR MODELS

Deposit maps (Figure 2) show the areal extent of various gravel deposits; maps can also show the thickness, depth, and depth to water table based on drilling or geophysical studies (Dunn, 1991; Smith and Collis, 1993, p. 4168). These features are commonly shown on contour maps (e.g., Robson, 1996). Aggregate quality, based on physical, chemical, and mechanical properties (Marek, 1991), can also be shown on maps. Many maps of aggregate resources, such as those of the Front Range Urban Corridor (Colton and Fitch, 1974; Trimble and Fitch, 1974a;b), are derived from geologic maps (Colton, 1978; Trimble and Machette, 1979a;b). Digital geologic maps (e.g., Green, 1992) are especially suitable for rapid reformatting and interpretation of sand and gravel resources. Map units can be recombined in a variety of ways to show the distribution of resources by quality, suitability, deposit model, or other criteria. The deposit map shown in figure 2

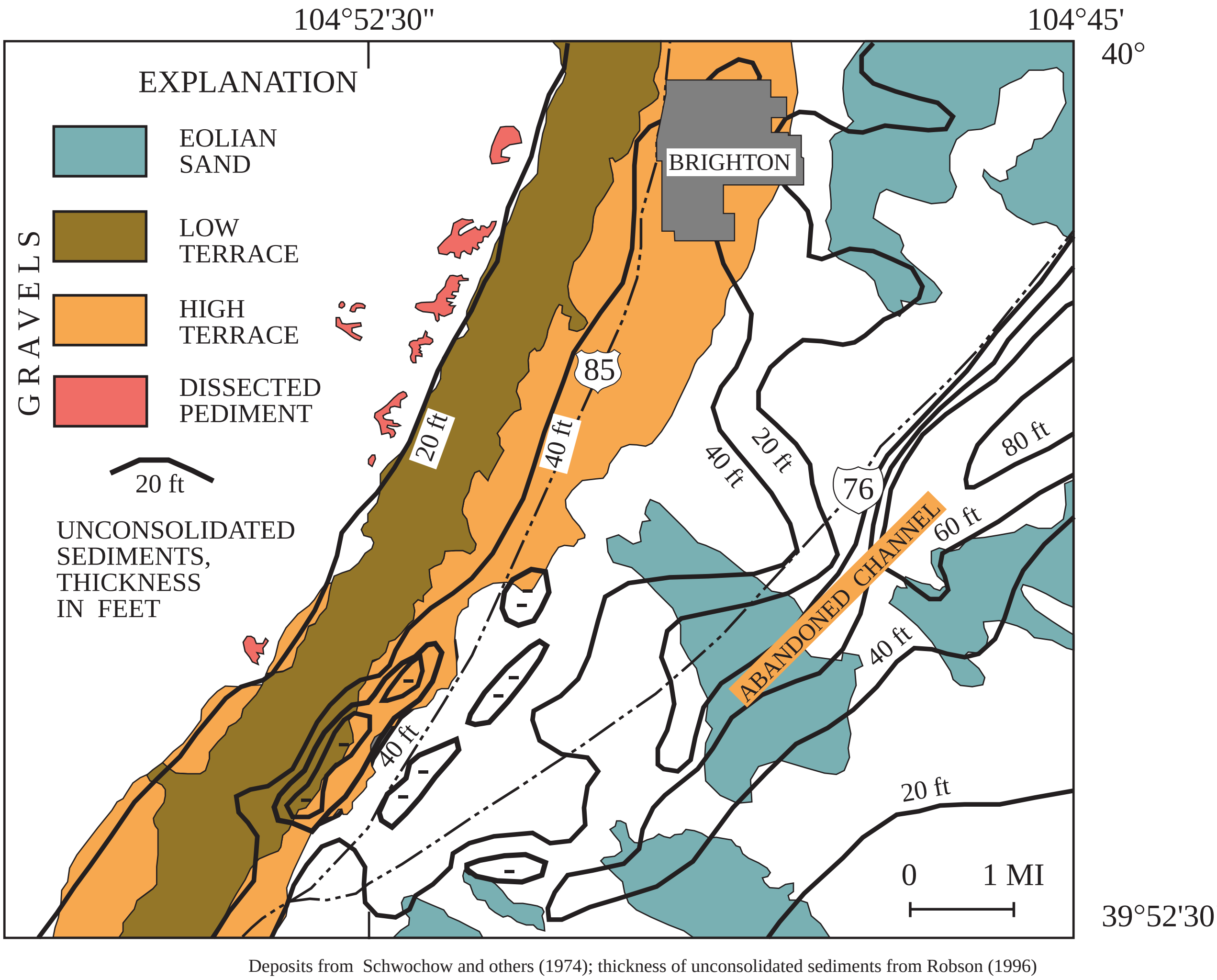

Figure 2.—Map showing sand and gravel deposits of the Brighton area, Colo., classified by model.

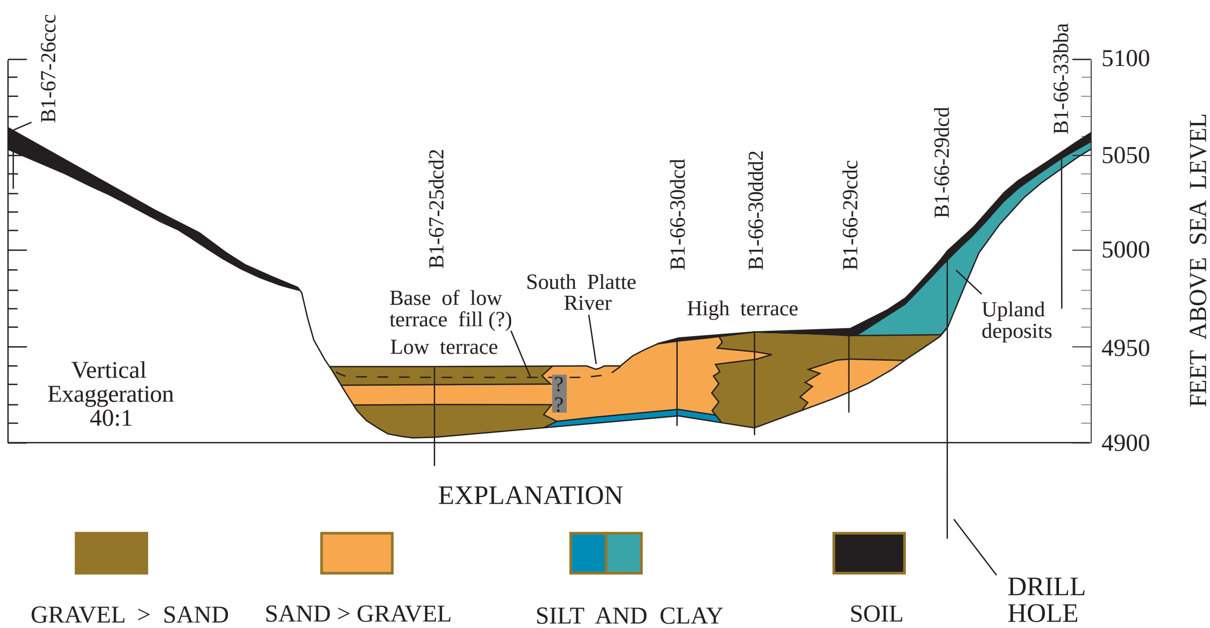

Figure 3.—Subsurface section, South Platte River Valley, Brighton, Colo., showing gravel layers.

Table 2.—Definitions of particle size used in the Front Range Urban Corridor

UNIT OF MEASURE	SILT AND CLAY	SAND	GRANULE GRAVEL	PEBBLE GRAVEL	OVERSIZE
Size in inches	0.0025	0.0025-0.079	0.079-0.158	0.158-2.5	>2.5
Size in mm	<0.0625	0.0625-2	2-4	4-64	>64
U.S. Sieve Series in mesh/inch	<230	230-10	10-5	5-0.4	<0.4

classifies resources by sand and gravel deposit model.

Subsurface sections (Figure 3), based on drillhole logs and geophysical exploration, show the thickness, depth, and lateral extent of sand and gravel along a line. Thickness of overburden and interbedded material that is too fine for use as aggregate can also be shown. The section shown in figure 3 was prepared from drillhole logs reported in the literature (Schneider, 1962). Uniform and accurate description by a trained observer is essential if drillhole logs are to be used to construct accurate subsurface sections. Geophysical exploration is usually calibrated with drillhole logs. Subsurface sections are particularly useful for three-dimensional visualization of a deposit.

Particle size, shape, and composition are among the properties that affect the suitability of an aggregate deposit for a specific commercial use (Marek, 1991; Smith and Collis, 1993, p. 145-306; Langer and Knepper, 1995). Maximum particle size is important because it determines requirements for crushing equipment. Particle size can be determined by sieve analyses or, for coarse sizes, by direct measurement at the deposit site. Size is usually specified by weight percent fines (silt and clay), sand, gravel, and oversize (cobbles and boulders). Definitions of size classes vary slightly; the particle size classification (Table 2) used by previous projects on the Front Range urban corridor (Colton and Fitch, 1974; Trimble and Fitch, 1974a,b) is shown here.

Particle shape, roundness, and surface textures affect strength (Marek, 1991). A detailed discussion of shape, roundness, and surface textures of sand and gravel particles is provided by Pettijohn (1975, p. 52-64). Shape is defined by the ratios of the three dimensions of a particle: particles tend to be spherical, rod-shaped, disc-shaped, or blade-shaped. Thin, blade-shaped particles tend to be weak, whereas equidimensional particles tend to be strong. Roundness refers to the degree to which a particle lacks angular corners; the greater the roundness, the weaker the bond with a cementing agent. The degree of roundness is determined by visual comparison with particle images assigned to a roundness scale ranging from very angular to well-rounded. A variety of surface textures and coatings also affect the bond between a particle and its cement. No data on particle shape, roundness, and surface textures in sand and gravel deposits of the Front Range Urban Corridor have been identified.

Composition refers to rock types, contained minerals, and chemical constituents, all of which are important to determining aggregate quality. Certain rocks contain silica minerals that react with Portland cement, resulting in rapid deterioration of concrete. Abundant clay minerals can indicate strongly weathered gravel with weak particles. Other deleterious materials include iron and manganese oxide, calcium carbonate, and gypsum; these substances commonly coat particles and fill interstices and cracks. Pebble counts, which are tabulations of various rock types identified in gravel, are available for part of the Front Range Urban Corridor (Colton and Fitch, 1974).

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