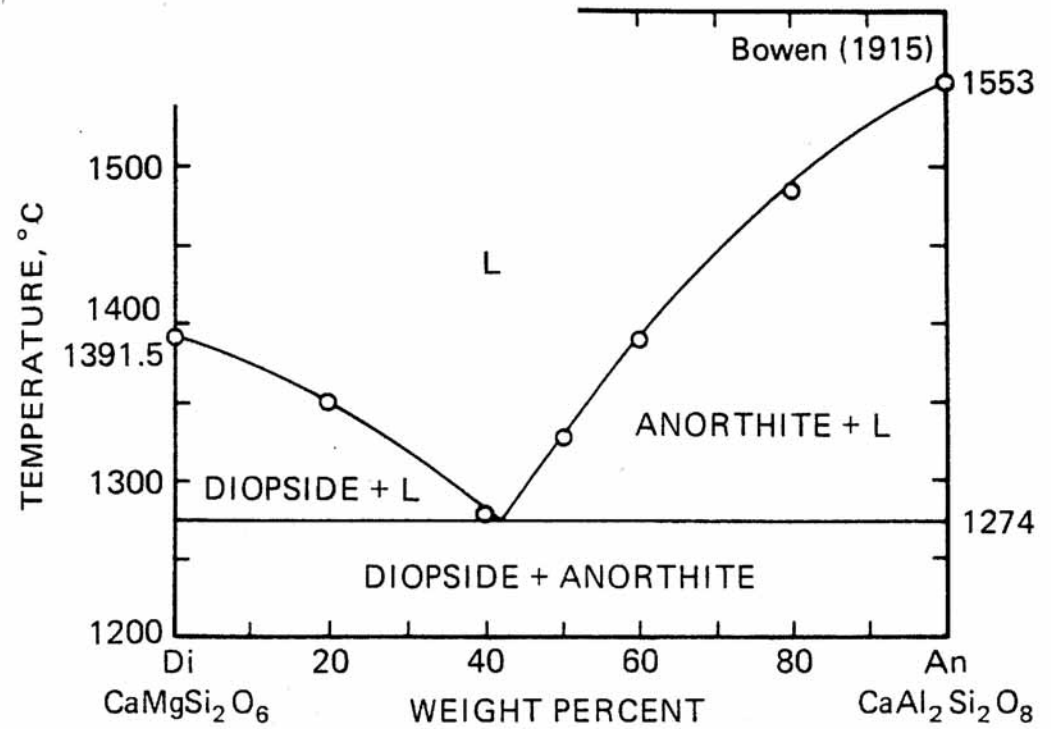


Announcements

Reading: p.59-73; p.207-208; 210-
211

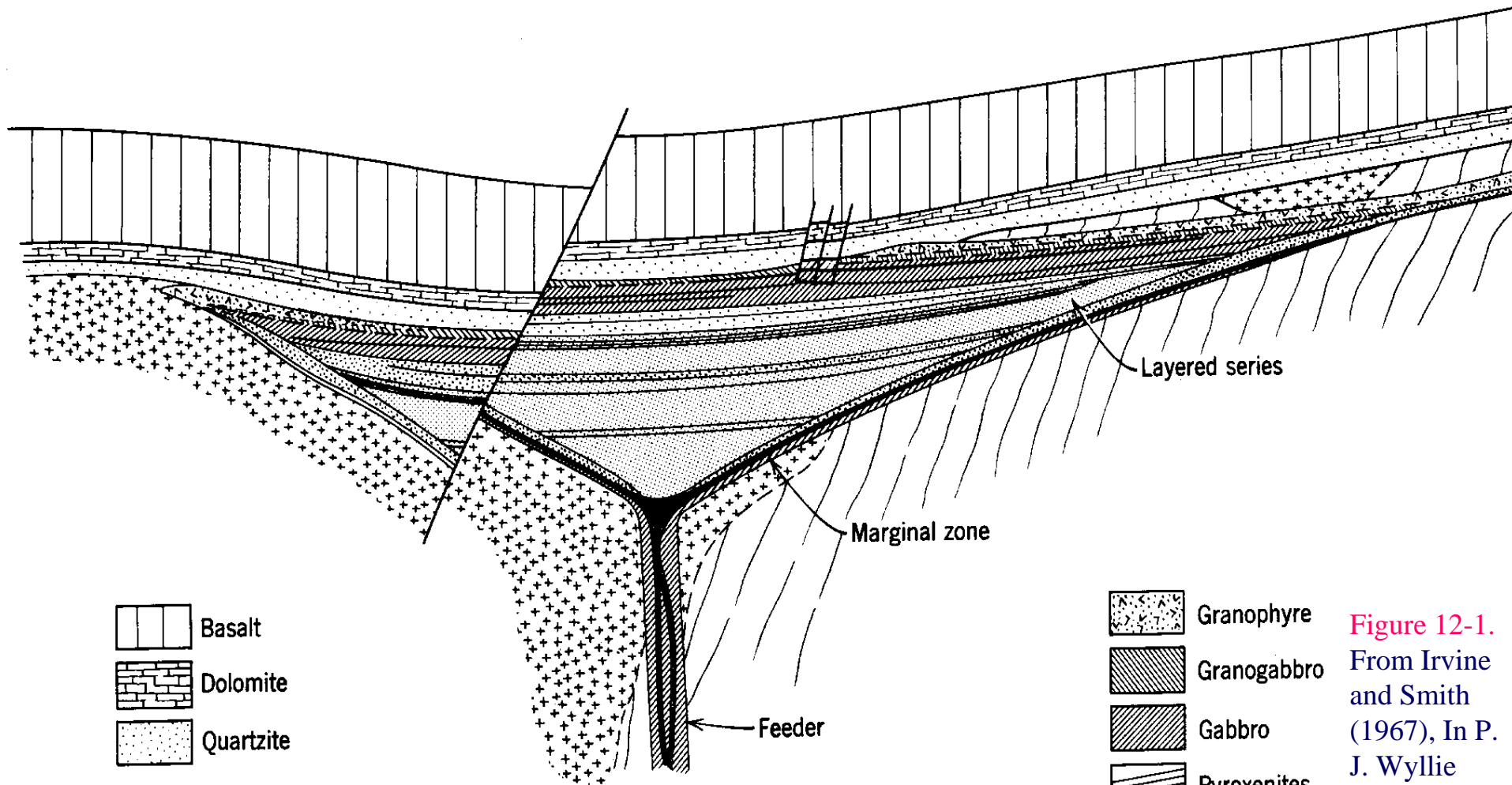
Di-An binary















Layered Mafic Intrusions: crystallization and differentiation

Name	Age	Location	Area (km ²)
Bushveld	Precambrian	S. Africa	66,000
Dufek	Jurassic	Antarctica	50,000
Duluth	Precambrian	Minnesota, USA	4,700
Stillwater	Precambrian	Montana, USA	4,400
Muskox	Precambrian	NW Terr. Canada	3,500
Great Dike	Precambrian	Zimbabwe	3,300
Kiglapait	Precambrian	Labrador	560
Skaergård	Eocene	East Greenland	100

exposed in continents, many associated with flood basalts,
generally Precambrian



-  Basalt
-  Dolomite
-  Quartzite
-  Granite
-  Metasediments

-  Granophyre
-  Granogabbro
-  Gabbro
-  Pyroxenites
-  Dunite
-  Peridotite
-  Picrite

The Muskox Intrusion

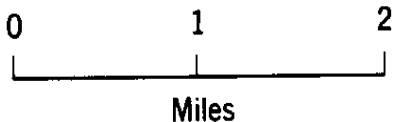


Figure 12-1.
 From Irvine and Smith (1967), In P. J. Wyllie (ed.), *Ultramafic and Related Rocks*. Wiley. New York, pp. 38-49.

Cumulate textures

- **Caution!** texture vs. paragenesis

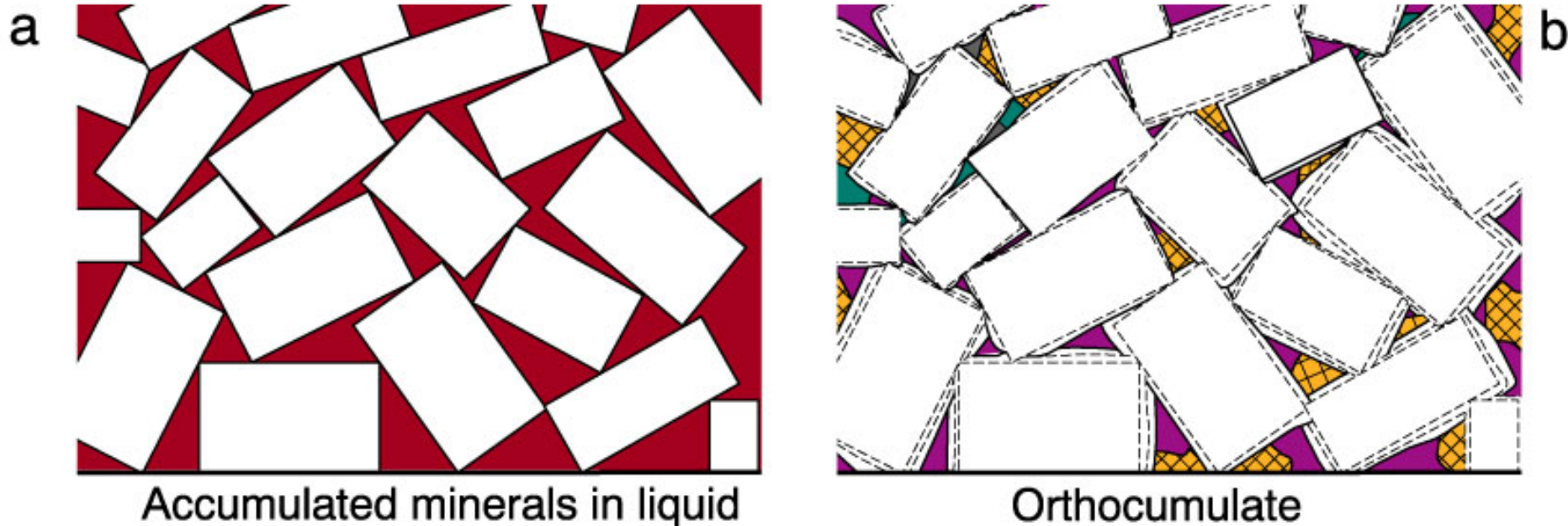


Figure 3-14. Development of **cumulate textures**. **a.** Crystals accumulate by crystal settling or simply form in place near the margins of the magma chamber. In this case plagioclase crystals (white) accumulate in mutual contact, and an intercumulus liquid (pink) fills the interstices. **b.** Orthocumulate: intercumulus liquid crystallizes to form additional plagioclase rims plus other phases in the interstitial volume (colored). There is little or no exchange between the intercumulus liquid and the main chamber. After Wager and Brown (1967), *Layered Igneous Rocks*. © Freeman. San Francisco.

Cumulate textures

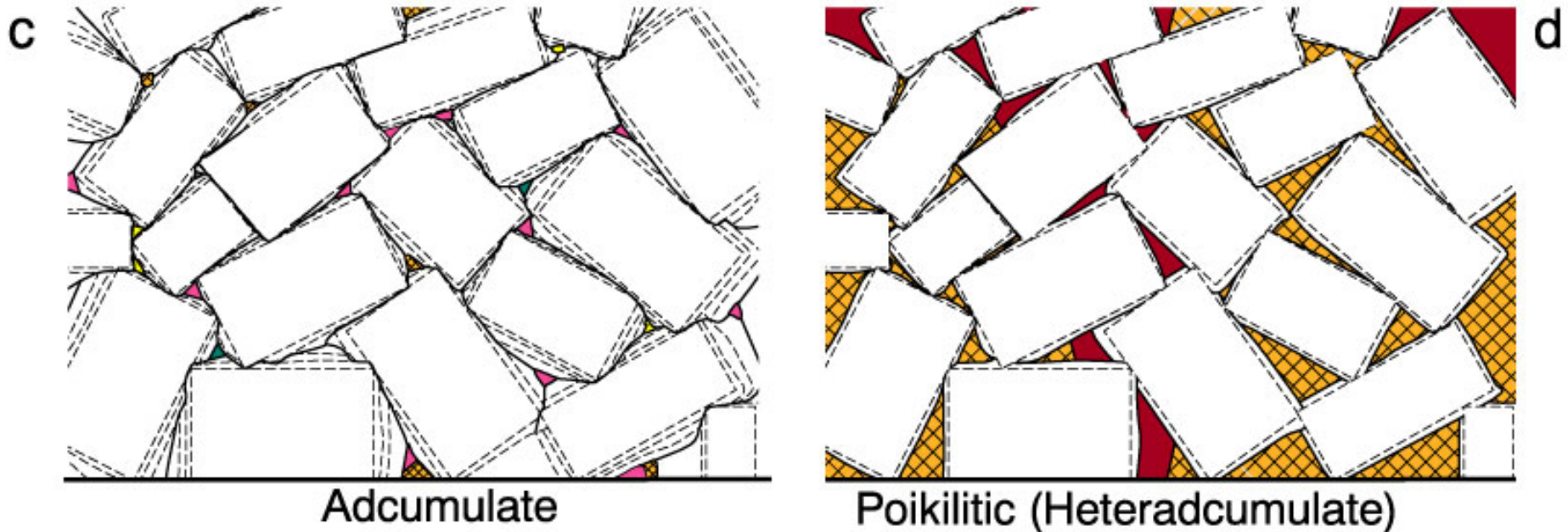


Figure 3-14. Development of **cumulate textures**. **c.** Adcumulates: open-system exchange between the intercumulus liquid and the main chamber (plus compaction of the cumulate pile) allows components that would otherwise create additional intercumulus minerals to escape, and plagioclase fills most of the available space. **d.** Heteradcumulate: intercumulus liquid crystallizes to additional plagioclase rims, plus other large minerals (hatched and shaded) that nucleate poorly and poikilitically envelop the plagioclases. . After Wager and Brown (1967), *Layered Igneous Rocks*. © Freeman. San Francisco.

Layering

layer: any sheet-like cumulate unit distinguished by its compositional and/or textural features

- **uniform** mineralogically and texturally homogeneous
- **non-uniform** vary either along or across the layering
 - **graded** = gradual variation in either
 - ✧ **mineralogy**
 - ✧ **grain size** - quite rare in gabbroic LMIs

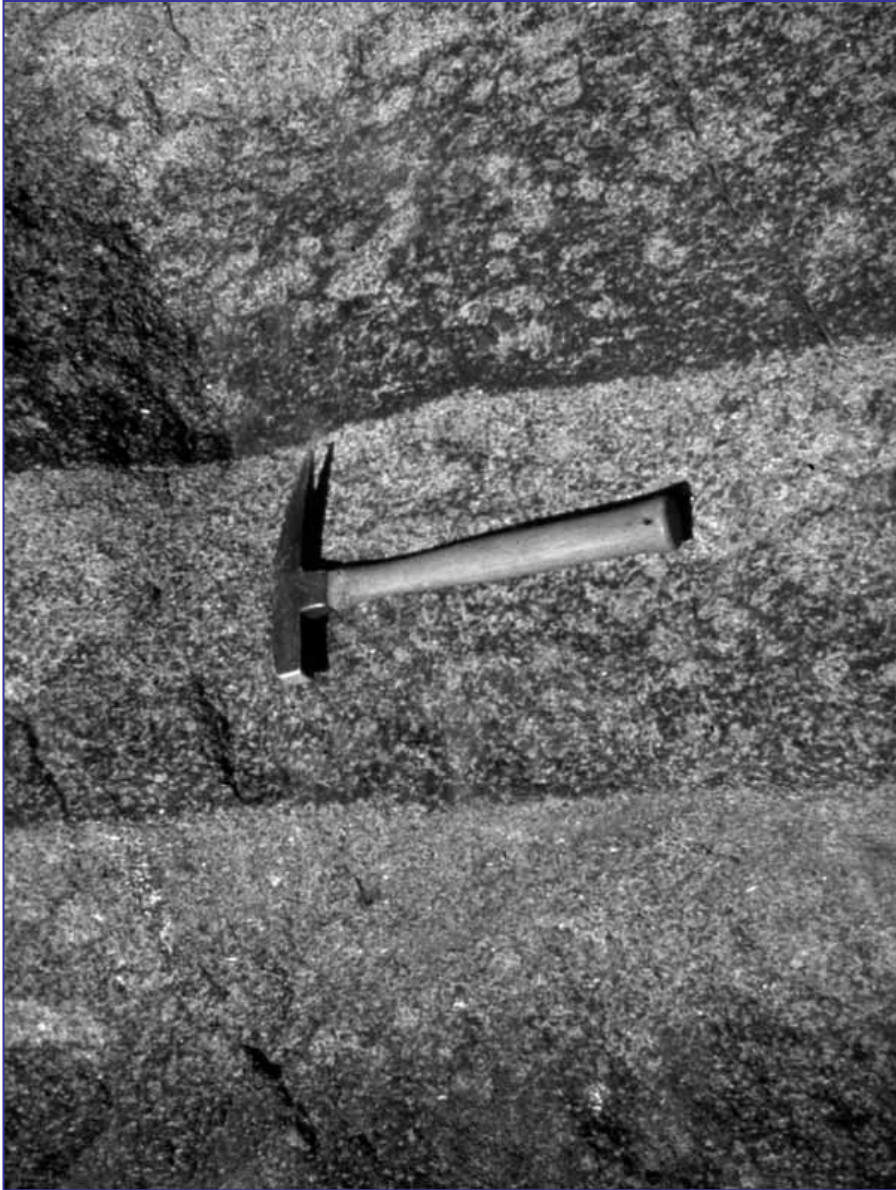
Uniform Layering

Figure 12-3b. Uniform chromite layers alternate with plagioclase-rich layers, Bushveld Complex, S. Africa. From McBirney and Noyes (1979) *J. Petrol.*, 20, 487-554.



Graded Layers

Figure 12-2. Modal and size graded layers. From McBirney and Noyes (1979) *J. Petrol.*, 20, 487-554.



Possible causes of modal layering

- Periodic large-scale convective overturn of the entire cooling unit
- ReInjection of more primitive magma
- In situ crystallization
- Density currents along walls and floor

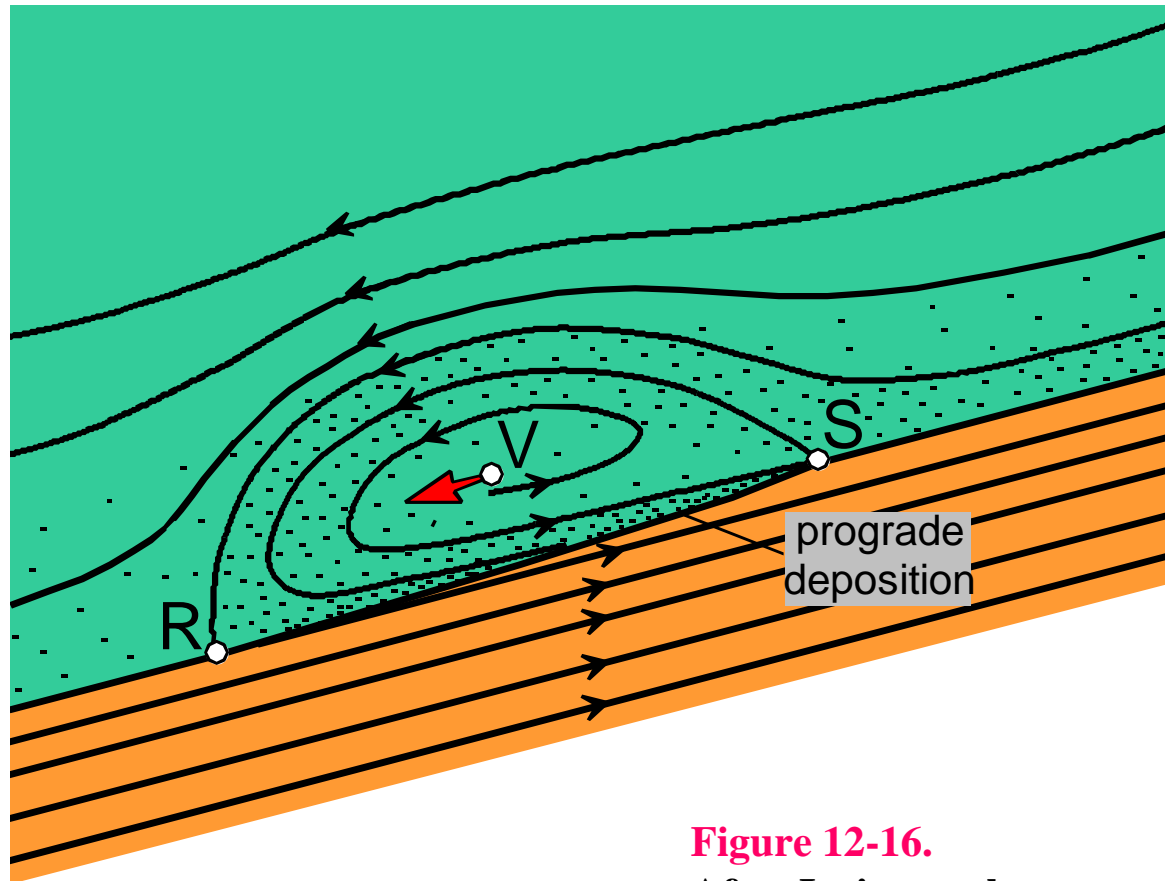


Figure 12-16.

After Irvine et al.
(1998) *Geol. Soc.
Amer. Bull.*, 110,
1398-1447.

Economic value of layered intrusions



4-10 g/t

Pt \$881/ oz Au \$439 / oz