The power of polydentate ligands

This page illustrates some complexes of Ni$^{2+}$ as a vehicle to consider the stability of complexes made by different kinds of ligands. The complexes shown all have N as the ligand atom for Ni$^{2+}$, which would be likely in view of the character of Ni$^{2+}$ as an intermediate cation. The point, however, is that polydentate ligands (ligands with more than one ligand atom), and especially cyclic polydentate ligands, are more stable than monodentate ligands.

**Ion:** Ni$^{2+}$

**Ligands:**
- Ammonia
- Ethylenediamine or "en"
- 2,3,2-tet, a tetraamine
- 1,4,8,11-tetraazacyclotetradecane or "cyclam"

**Complexes:**
- Complex with six monodentate ligands
- Complex with three bent bidentate ligands
- Complex with one bent tetradeate ligand
- Complex with one undeformed cyclic tetradeate ligand

**Stability:**

Both of these complexes involve six N ligand atoms, but the complex on the right involves bidentate ligands. Of these two complexes, the complex with the polydentate ligand is far more stable:

\[
\text{Ni}^{2+}(\text{aq}) + 6\text{NH}_3 \rightarrow \text{Ni(NH}_3)_6^{2+} \quad \log K = 8.6
\]

\[
\text{Ni}^{2+}(\text{aq}) + 3\text{en} \rightarrow \text{Ni(en)}_3^{2+} \quad \log K = 18.3
\]

Both of these complexes involve one ligand with four N ligand atoms. Of these two complexes, the complex with the cyclic ligand is far more stable, with a stability constant about $10^6$ times that of the linear ligand. This far greater stability is typical of cyclic ligands.